tively short period of time, so that the resultant shrinkage of the mass will take place before it is necessary to pressure grout the construction joints and impound water behind the dam. The chemical action in setting concrete develops a large amount of heat, which heat is rapidly dissipated by radiation when in masses of small dimensions. On the other hand, this heat radiation from large masses is relatively very slow and varies as the square of the dimensions of the mass. On this basis the degree of cooling that would naturally take place by radiation from a mass 50 feet in thickness (a representative dimension for concrete arch dams of ordinary magnitude) in one years' time would require a century if the structure were 500 feet thick, which may be taken as the average thickness of the Hoover Dam. Shrinkage in the mass will continue until the setting heat is dissipated. To correct for this and to make the structure monolithic and water-tight, the contraction joints provided for this purpose will be filled with cement grout under pressure after the cement has cooled. The artificial cooling is therefore required in order to permit the completion and use of the dam within a permissible period of time. The rated capacity of the cooling plant is 600 tons per day.

The circulating pipes in the concrete are to be spaced 10 feet apart vertically and about 11⅓ feet apart horizontally. The approximate basis for estimating the amount of heat to be removed is 50,000 to 60,000 B. t. u. per cubic yard of concrete as an average condition. Data of record relative to the thermal properties of concrete are comparatively meager and, in some instances, apparently erroneous. A suitable series of experiments will be conducted to establish these properties for the specific materials to be used before concrete placing is begun.

The injurious effects to be anticipated if no provision were made for artificial cooling are the cracking of the concrete and the opening up of the construction joints due to shrinkage from cooling after the structure is completed and put in use. Such cracks and open construction joints would invite leakage and would disarrange the distribution of stresses between the arch and cantilever elements, which would result in concentrated stresses much higher than calculated in the design of the dam due to the structure not being able to act as a monolith.

The turning of the river to permit the unwatering of the actual dam site is no mean undertaking. To do this, four tunnels are to be driven, two on the Nevada side and two on the Arizona side of the river. The bottom elevation of these tunnels will be about the low-water flow line of the river. Each tunnel will be about 50 feet in diameter when finished, and the combined capacities of all four will be about sufficient to take care of the average flow of the Mississippi River at St. Louis. The capacity will be 200,000 cubic feet of water per second. When these tunnels are completed, cofferdams of rock-fill construction, faced upstream with steel-pile cut-off walls, will be constructed, one just below the upstream intakes and one just above the downstream discharge ends of the tunnels. These cut-off dams will raise the water at the upstream end and divert the flow of the river through the completed tunnels, and the downstream dam will prevent the water from backing up and flooding the site.

After the main dam is completed, all four of the tunnels will be plugged at the upstream ends. One tunnel on each side of the river will be used for a spillway by connecting with a slanting shaft having its upper end at the water surface of filled reservoir. The other two tunnels will be plugged at both ends and will be utilized as pressure tunnels to connect with the control gates in the inlet towers.

SOME FIGURES ON THE HOOVER DAM

In order to gain some conception of the magnitude of this great project it does not seem out of place to list some of the items that will enter into it.

Tunnels.—Combined length, 3.1 miles; cubic yards of excavation in rock, 1,900,000.

Cofferdams.—1,200,000 cubic yards of rock and earth fill.

Reinforcing steel bars and rails.—35,500,000 pounds.

Concrete.—4,400,000 cubic yards.

Miscellaneous items.—Small metal pipe and fittings, 1,900,000 pounds; structural steel, 10,600,000 pounds; large metal conduits, 32,500,000 pounds; metal work, gates, hoists, etc., 20,000,000 pounds.

Time to build.—About six or seven years.

It is estimated that it will require about 350 carloads of material daily to keep up with the demand for supplies during the construction period.

Even the seemingly simple element of elevator service looms rather large when it is realized that enough workmen to man a good-sized manufacturing plant must be handled in and out of a canyon over a thousand feet deep.

This dam will be the Government's answer to a series of vexing problems that have developed in connection with the river and will, as has been aptly said, "Convert a natural menace into a national resource" and will mark one more milepost in man's struggle against nature.

SOUNDING-BALLOON OBSERVATIONS MADE AT BROKEN ARROW, OKLA., DURING THE INTERNATIONAL MONTH, DECEMBER, 1929

By L. T. SAMUELS

[Weather Bureau, Washington, D. C., July, 1931]

In cooperation with the International Commission for the Exploration of the Upper Atmosphere the Weather Bureau conducted a series of sounding-balloon observations at the Broken Arrow[1] (Okla.) aerological station during the international month, December, 1929. The instruments used were of the Fergusson type. The balloons were made of seamless rubber and weighed between 575 and 1,238 grams. They were spherical in shape, between 75 and 100 centimeters diameter, and were inflated to between 137 and 158 centimeters diameter. This gave a free lift of approximately 500 grams and an ascensional rate of about 238 meters per minute.

The balloons were released daily about one hour before sunset so as to eliminate, so far as possible, the effects of insolation on the meteorograph and still make possible the use of theodolites to follow the balloons. On the 17th, 18th, and 19th (international days) additional balloons were released shortly after sunrise. There were 34 observations made, and 26 (76 per cent) of the instruments were returned. One of the latter had the record sheet removed and another had a faulty pressure record. Of the eight instruments not returned, three were followed with two theodolites to the following heights, viz, 13,175 meters on the 2d, 7,420 meters on the 26th, and 17,590 meters on the 30th. Wind velocities and directions were determined to those elevations.

The balloons were followed with two theodolites whenever possible, and in nine cases these continued for 60 minutes or more, the longest run being 90 minutes on the 25th.

[1] Latitude 36° 02′ N., longitude 95° 49′ W.

The altitudes as determined from 2-theodolite observations and those obtained hypsometrically were in close agreement in most cases. The differences averaged less then 5 per cent. At levels below 10,000 meters the altitudes obtained hypsometrically averaged slightly less than those determined from the 2-theodolite readings and slightly greater at altitudes above 10,000 meters.

The 2-theodolite altitudes were corrected for the curvature of the earth's surface, which correction is additive and amounts to approximately 100 meters when the horizontal distance of the balloon is 35,000 meters and to 1,000 meters when this distance is around 113,000 meters. In some cases the balloon was observed to a horizontal distance of 120,000 meters, the curvature correction for that distance being 1,130 meters.

It will be noted from Figure 1 that practically all of the instruments landed within 200 kilometers of the station and none was found to the westward. The maximum distance from which an instrument was returned was 450

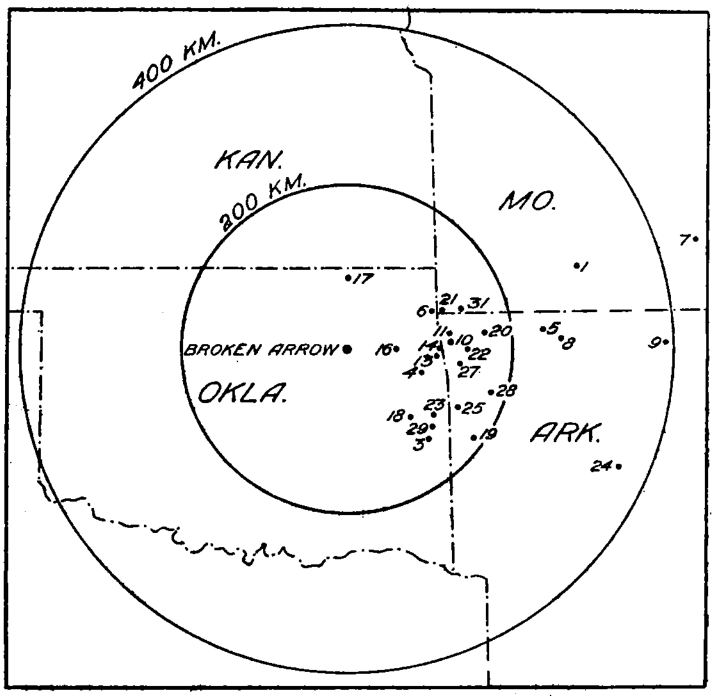

FIGURE 1.—Landing places (with dates) of meteorographs released from Broken Arrow, Okla., during December, 1929

kilometers. This one was released on the 7th and encountered exceptionally strong winds. The balloon was lost to view at 13,200 meters, at which elevation the wind was 60 meters per second from the west-southwest. It was apparently stronger at still greater heights. The weather map of that date indicates an interesting relation between this strong wind and the exceedingly rapid movement of a low-pressure area centered to the northeast of Broken Arrow, accompanied by a rather steep NW.-SE. surface temperature gradient in its rear. Twenty-four hours later this low was centered 2,000 kilometers to the northeast.

The highest elevation reached during the month was 22,921 meters on the 25th. In 17 cases the maximum heights exceeded 15 kilometers; in 6 of these cases the balloons were of the largest size used, i. e., between 91 and 107 centimeters diameter, whereas, with the exception of 2 cases, all of the other balloons were smaller, i. e., 76 centimeters diameter. In the two cases referred to above the heights reached were more than 13 kilometers. It is therefore evident that the larger balloons proved to be the best for reaching high altitudes.

TEMPERATURE

The lowest temperature recorded during the series was −80.8° C. at 15,191 meters on the 13th. At that altitude the pressure record was obliterated, but the temperature trace shows a further fall to −81.7° C. at apparently 1 kilometer higher. This is the lowest temperature ever recorded on this continent, the previous record being −79.4° C. at 14.8 kilometers at St. Louis, Mo., on January 25, 1905.[1] The low mark of −81.7° C. seems to be confirmed by the observation of the following day (14th), when −77.0° C. was recorded at 16,142 meters. The weather maps of those two days show practically the entire country to have been dominated by large high-pressure areas, with centers over the southern plateau and South Atlantic States, the Canadian Northwest, and and Canadian Maritime Provinces, low-pressure areas being conspicuously absent.

Likewise, the map of January 25, 1905, shows St. Louis to have been close to the center of an exceptionally strong high-pressure area (31.1 inches). It is also found that on the day when the minimum temperature of −78.3° C. at 17,467 meters on October 9, 1927, was recorded during the sounding-balloon series at Groesbeck, Tex. (2), the country was covered by a very extensive high-pressure area.

It seems probable that these very low temperatures in the stratosphere are associated with the cold currents of "equatorial fronts."[2] Unfortunately upper air wind observations were impossible on these days because of cloud conditions over Broken Arrow, the sky being practically covered with stratus moving from the south-southwest.

The following are some of the significant features of the tropopause obtained for the more recent monthly series of sounding-balloon observations made in this country:

	Date	Mean height of tropopause	Mean temperature of tropopause	Maximum height of tropopause observed	Minimum height of tropopause observed	Range in height of tropopause observed
		Meters	° *C.*	*Meters*	*Meters*	*Meters*
Br	Dec. 1929	10,083	−54.0	12,212	7,728	4,484
Groesbeck, Tex. (2)	Oct. 1927	14,823	−65.5	17,467	11,695	5,772
Royal Center, Ind. (3)	May 1926	12,011	−58.4	15,840	8,878	6,962

The variations found between these stations are very probably the result of both a geographical and seasonal effect.

The altitude and temperature of the tropopause, for the individual observations with the corresponding dates are shown, together with the mean temperature curve, in Figure 2. The usual inverse relationship between temperature and height of the tropopause will be noted.

In Table 1 may be seen the progressive rise and fall of the tropopause during the latter part of the month, when observations of the stratosphere were obtained on several

[1] Annals Harvard College Observatory, vol. 68, pt. 1.

[2] The expression "equatorial front" is used by Willett in Bulletin National Research Council No. 79, Dynamic Meteorology, p. 229, as the antithesis, in a much modified degree, of the well-known expression "polar front."—ED.

consecutive days. It will be noted that a progressive decrease in height occurs from the 19th to the 21st; then an increase in height to the 25th, followed by another general decrease.

The direct relationship usually found between the sea-level pressure and the height of the tropopause was decidedly abnormal. During the latter part of the month, when the tropopause was low, the sea-level pressure was in general above normal, the maximum departure, +0.386 inch, occurring on the same day (21st) that the lowest tropopause was recorded. Likewise, on the 25th, when the highest tropopause was recorded, the sea-level pressure was 0.078 inch *below* normal. In this connection it is noted that there was no apparent connection between the height of the tropopause and the sea-level pressure found at Groesbeck in the series of October, 1927 (2). It would seem that this direct relationship occurs only in the higher latitudes.

In Figure 3 are shown the individual temperature-altitude curves. The surface temperature is indicated at the bottom of each curve and the temperature at the maximum altitude at the top. The wind directions whenever observed are indicated adjacent to the corresponding curves for the standard levels. Attention is invited to the curves for the 7th, 20th, 22d, and 27th, where a south wind component occurs, together with a relatively large decrease of temperature, *within* the stratosphere. This, it appears, is associated with the "equatorial front."

In general when the tropopause is high the lower part of the stratosphere is characterized by a relatively large inversion. This, of course, tends to equalize the temperature in the higher levels of the stratosphere.

The maximum average lapse rate was 0.77° C./100 meters and occurred between 6 and 7 kilometers. (See Fig. 2.) At the Groesbeck (2) this value was 0.79° C./100 meters, and at Royal Center (3), 0.71° C./100 meters. At both of the latter stations, however, this maximum average lapse rate occurred at a slightly greater altitude, viz, between 7 and 8 kilometers.

In Figure 4 are shown the free-air isotherms for the month with the dates indicated across the top. The average height of the tropopause at 10 kilometers is well brought out in this chart. The pronounced isothermal conditions in the stratosphere during the last decade of the month, when most of the higher observations were obtained, are clearly evident.

WIND

Figure 5 shows the mean wind velocity and direction curves for the month. The mean velocities and mean directions were determined independently of each other. It will be noted that the mean velocity reaches a maximum (37.5 m. p. s.) at 11 kilometers, i. e., 1 kilometer above the mean height of the tropopause. Above this height the average velocity decreases at a somewhat lower rate than that at which it increased in the lower levels which indicates a still lower value at altitudes above 21 kilometers.

The mean wind direction veers from south of west below 1,200 meters to north of west, above, up to 21 kilometers, where it is west.

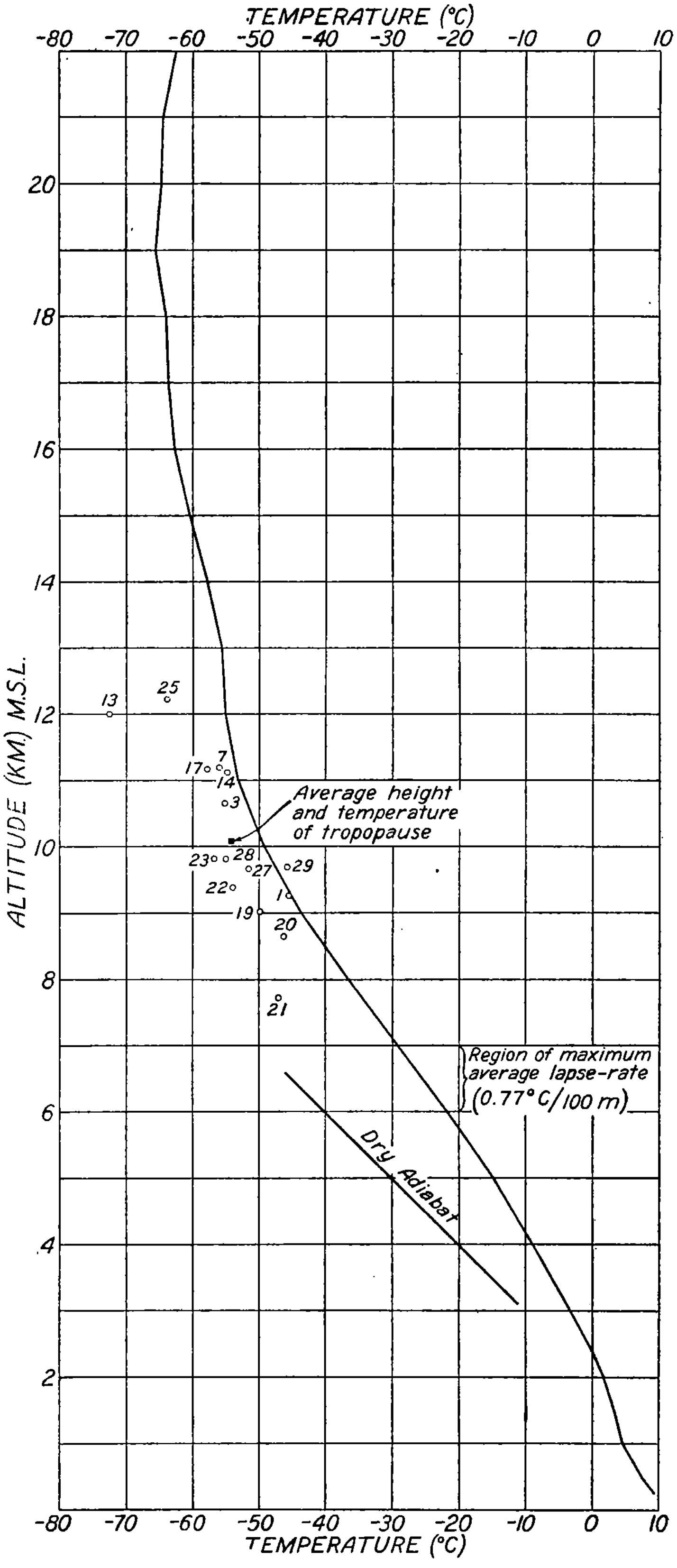

FIGURE 2.—Mean temperature curve (° C.) for December, 1929, Broken Arrow, Okla. (Circles indicate height and temperature of tropopause with corresponding dates)

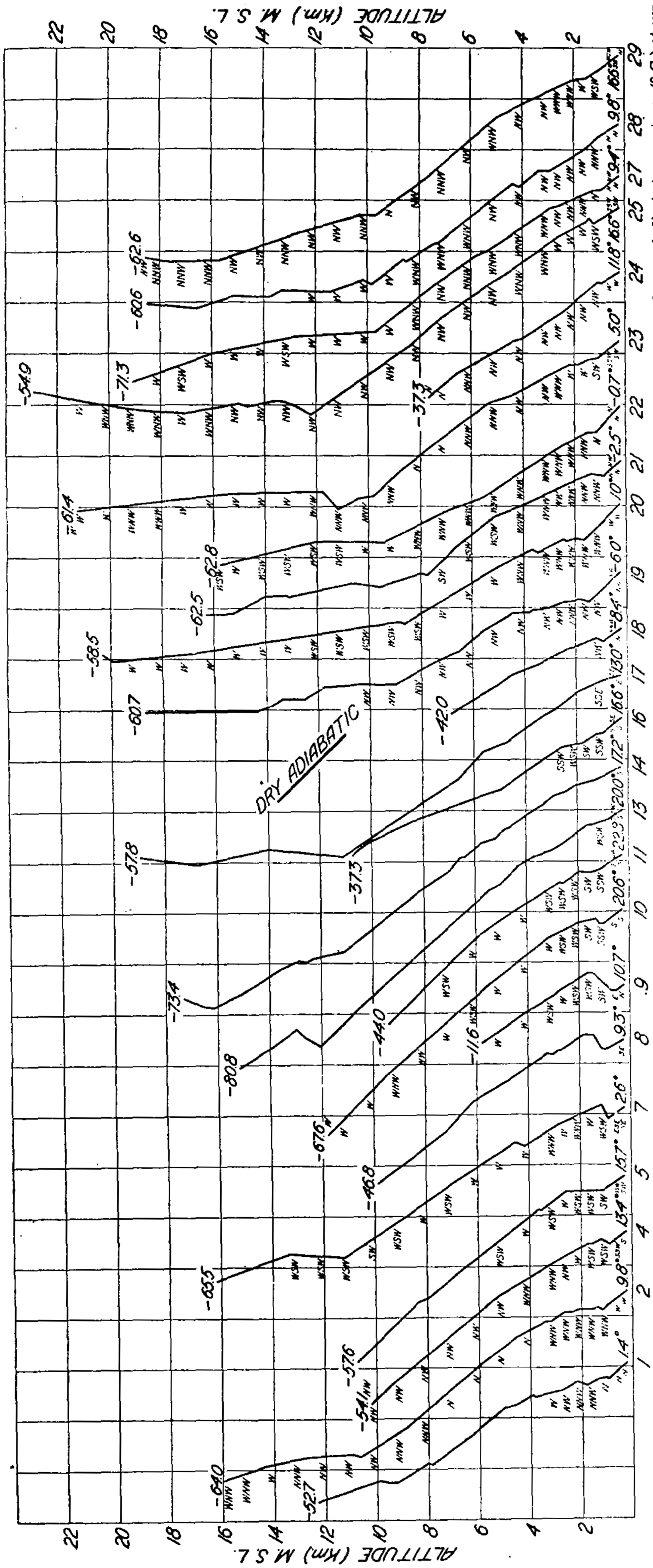

FIGURE 3.—Temperature-altitude curves for individual observations made at Broken Arrow, Okla., during December, 1929. (Dates indicated below.) (Figures at bottom and top of curves indicate temperatures (° C.) at surface and at maximum altitudes; abscissa value of each square corresponds to 20° C. of temperature)

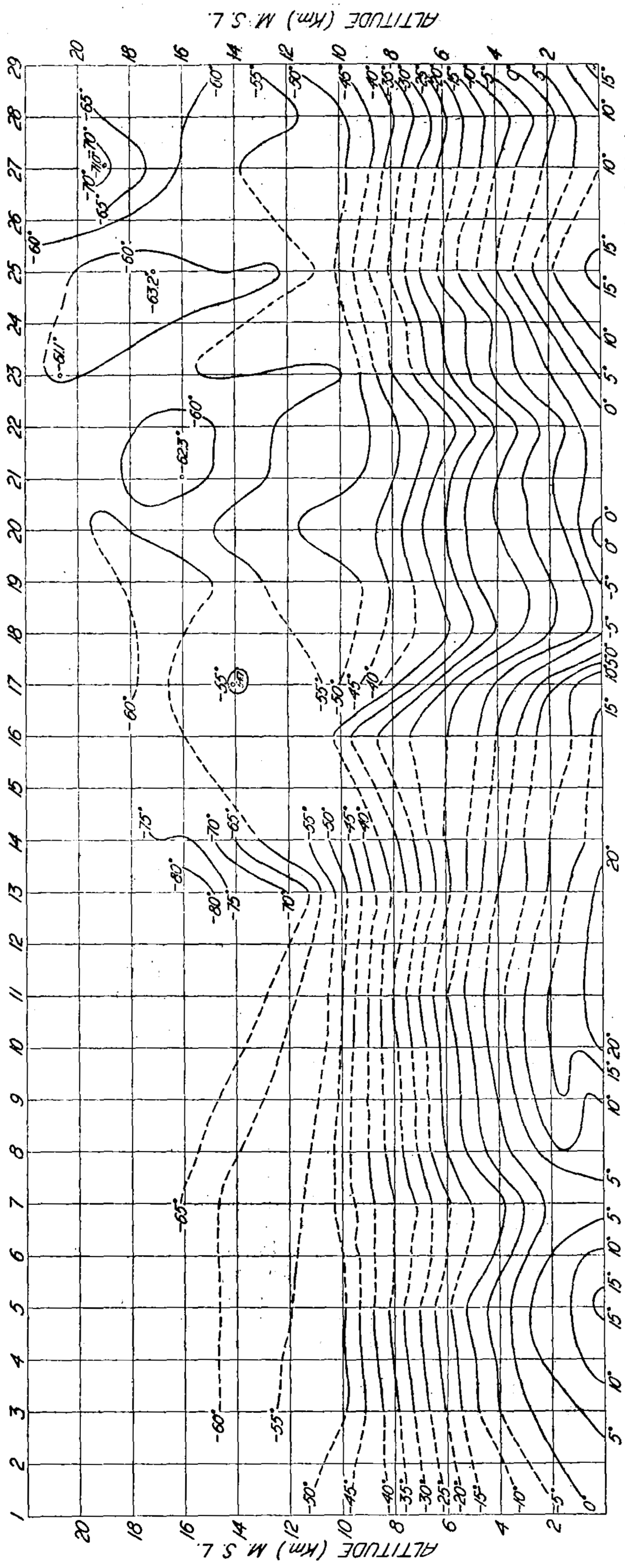

FIGURE 4.—Free-air isotherms (° C.) observed at Broken Arrow, Okla., during December, 1929. (Broken lines drawn between missing days with observations) (Dates indicated at top)

The individual wind velocity curves are shown in Figure 6. The general increase in velocity from the ground to the tropopause is evident and also the decrease within the stratosphere.

Figure 7 shows the wind-direction curves for each observation. The rapid shift to northwesterly between the surface and 2 kilometers is clearly indicated. In no case was a shift to easterly found at the highest levels as at Groesbeck in October, 1927 (2). However, it will be noted that in three cases (3d, 10th, and 29th) the direction at the upper extremities of the curves reaching to high altitudes (above 18 kilometers) veers toward the north. This characteristic is very similar to the curves for Groesbeck (2), where the veering continued past north into east. It seems very probable, therefore, that at somewhat greater heights the upper easterly winds would have been observed at Broken Arrow.

RELATIVE HUMIDITY

Figure 8 shows the mean relative humidity for the month. However, on account of the increasing lag of the hair hygrometric element at temperatures below −15° C., the mean humidity values must be accepted with reservation above 5 kilometers.

For references to previous sounding-balloon series made in this country see MONTHLY WEATHER REVIEW, June, 1929, pages 231–246, and July, 1927, page 302.

TABLE 1.—*Summary of sounding-balloon observations made at Broken Arrow, Okla., during December, 1929*

Date	Time of release, 90th mer.	Stratosphere: Height of base, M. S. L.	Stratosphere: Temperature at base	Maximum height reached, M. S. L.	Minimum temperature recorded	Theodolite observations: 2-theodolite	Theodolite observations: 1-theodolite	Meteorograph found: Distance from station	Meteorograph found: Direction from station
		M.	*° C.*	*M.*	*° C.*	*Min.*	*Min.*	*Km.*	
1	4:23 p.	9, 272	−45. 4	12, 327	−52. 7	4	16	300	ENE.
2	4:24 p.			13, 175		60		(1)	
3	4:04 p.	10, 639	−55. 0	15, 957	−64. 0	49	82	145	SE.
4	4:21 p.			[2] 19, 600	−54. 1	72	78	84	SE.
5	4:07 p.			10, 759	−57. 6	21	28	250	E.
6	4:13 p.					5		110	ENE.
7	4:22 p.	11, 206	−55. 9	16, 181	−65. 5	53	55	450	ENE.
8	3:39 p.			9, 900	−46. 8	16	22	270	E.
9	3:59 p.			5, 783	−11. 6	10	21	385	E.
10	3:58 p.			[2] 20, 300	−67. 6	80	85	127	E.
11	4:17 p.			9, 402	−44. 0	20	30	127	E.
12	4:20 p.					0	15	(1)	
13	4:19 p.	12, 000	−72. 5	15, 191	−81. 7	2	5	110	E.
14	4:25 p.	11, 112	−55. 2	17, 304	−77. 0	0	1	110	E.
15	4:03 p.					0	1	(1)	
16	4:12 p.			10, 764	−37. 3	5	14	63	E.
17	7:27 a.	11, 072	−57. 8	18, 962	−60. 7	0	4	85	N.
17	4:21 p.					1		(1)	
18	7:52 a.					3		(1)	
18	4:45 p.			6, 874	−42. 0	0	5	120	SE.
19	7:30 a.							(1)	
19	4:10 p.	8, 999	−50. 1	18, 704	−60. 7	48	51	185	SE.
20	4:01 p.	8, 652	−46. 2	20, 355	−60. 9	[3] 83		145	ESE.
21	4:26 p.	7, 728	−47. 1	16, 334	−62. 5	21		125	ENE.
22	3:32 p.	9, 386	−54. 1	17, 790	−62. 8	53	66	170	E.
23	4:12 p.	9, 820	−56. 8	21, 289	−61. 4	78	86	125	SE.
24	4:04 p.			[2] 13, 070	−37. 3	40	50	365	ESE.
25	3:49 p.	12, 212	−63. 8	22, 921	−63. 8	90		150	ESE.
26	4:04 p.			7, 420		27		(1)	
27	4:21 p.	9, 660	−51. 5	19, 078	−71. 3	69		160	E.
28	4:22	9, 807	−53. 0	18, 519	−62. 3	46	56	190	ESE.
29	3:44 p.	9, 686	−45. 8	18, 550	−64. 1	74	83	136	SE.
30	4:08 p.			15, 611		65	73	(1)	
31	4:10 p.			[1] 5, 183	(4)	21	23	160	NE.

[1] Not found. [2] Maximum altitude from 2-theodolite observation.

[3] In the two theodolite observation of the 20th, the balloon was observed until its horizontal distance from the place of observation was 122 km., at which time the balloon had reached an altitude of 18 kms. and had been in the air 83 minutes. So far as is known, this is the greatest horizontal distance to which a balloon has ever been observed by two theodolites.

[4] Record sheet lost.

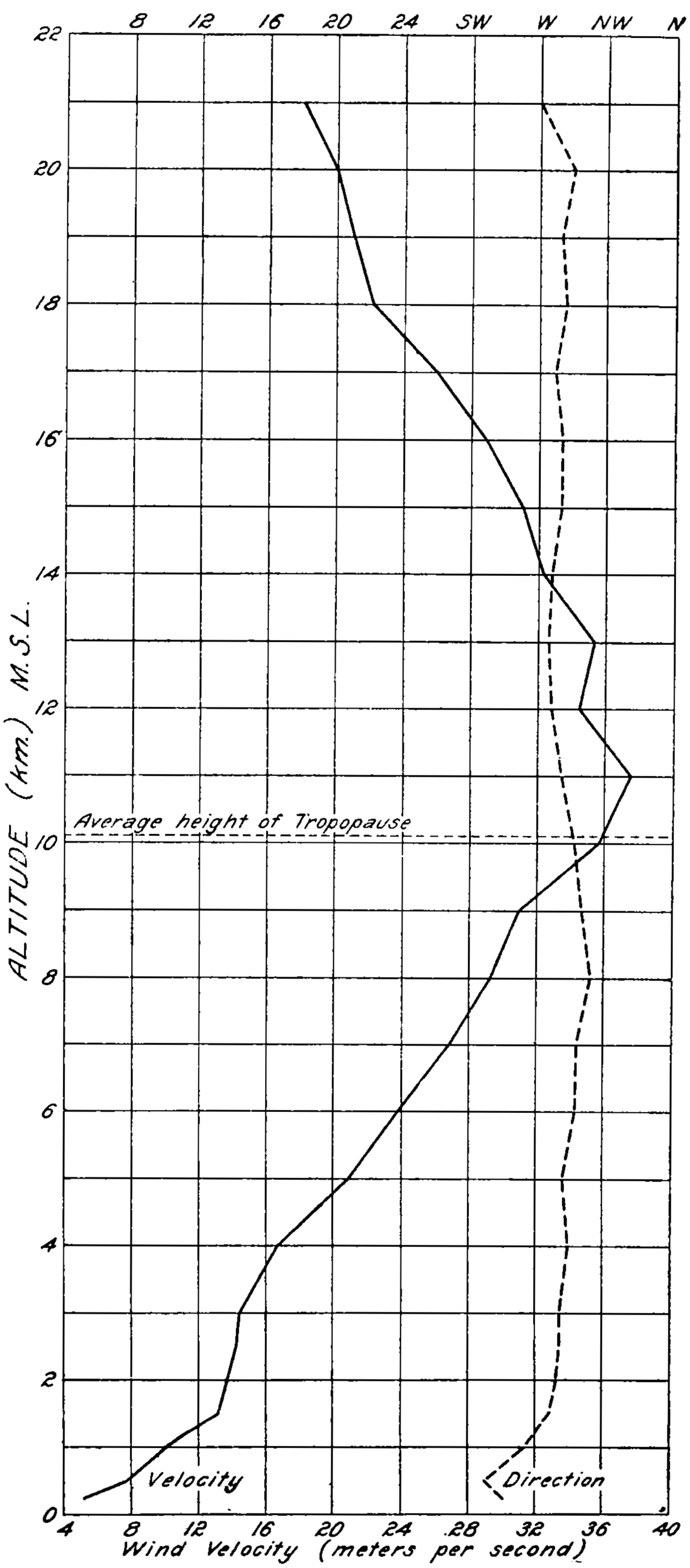

FIGURE 5.—Mean wind velocity (m.p.s.) and direction curves observed at Broken Arrow, Okla., during December, 1929

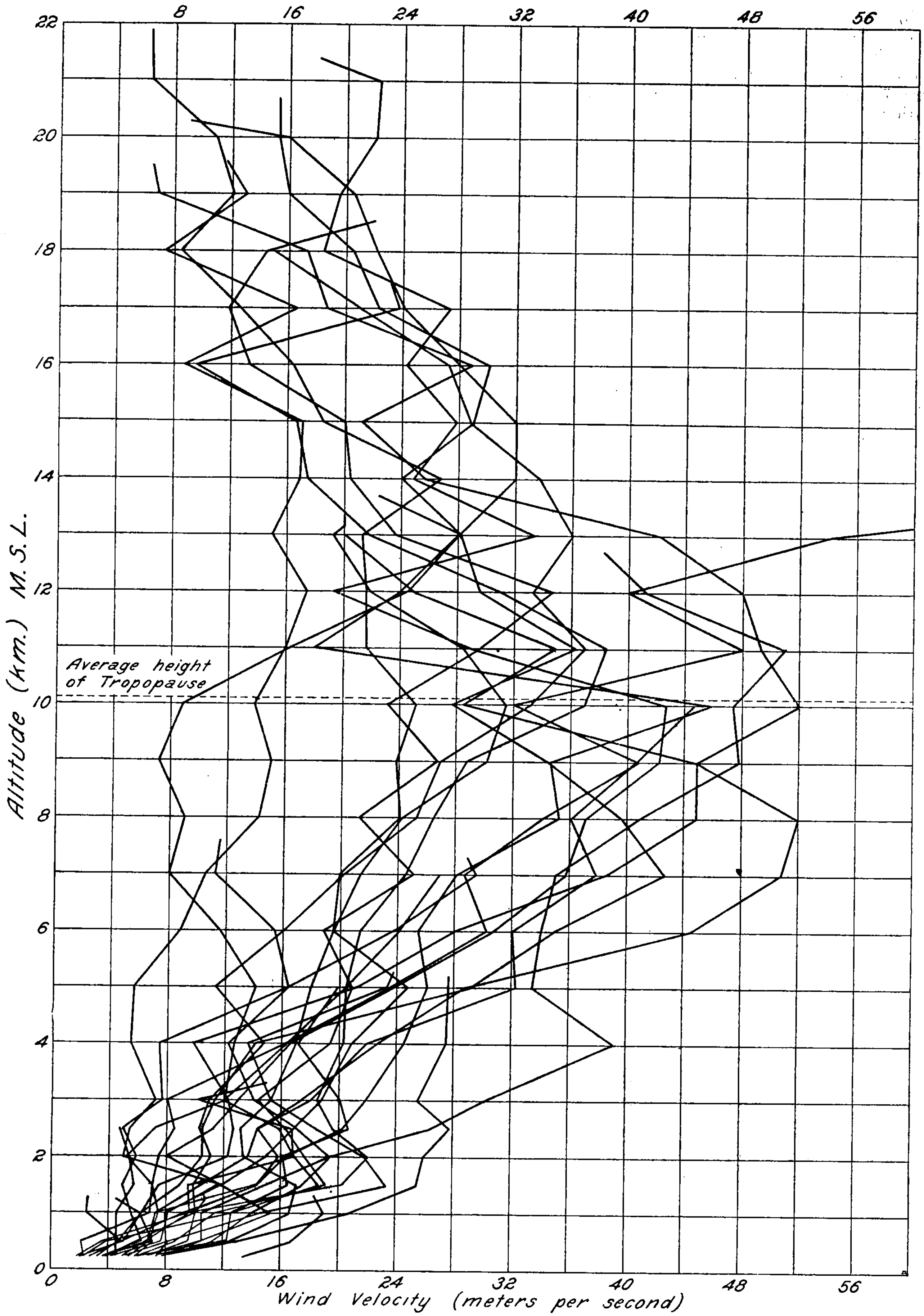

FIGURE 6.—Wind-velocity curves for individual observations made at Broken Arrow, Okla., during December, 1929

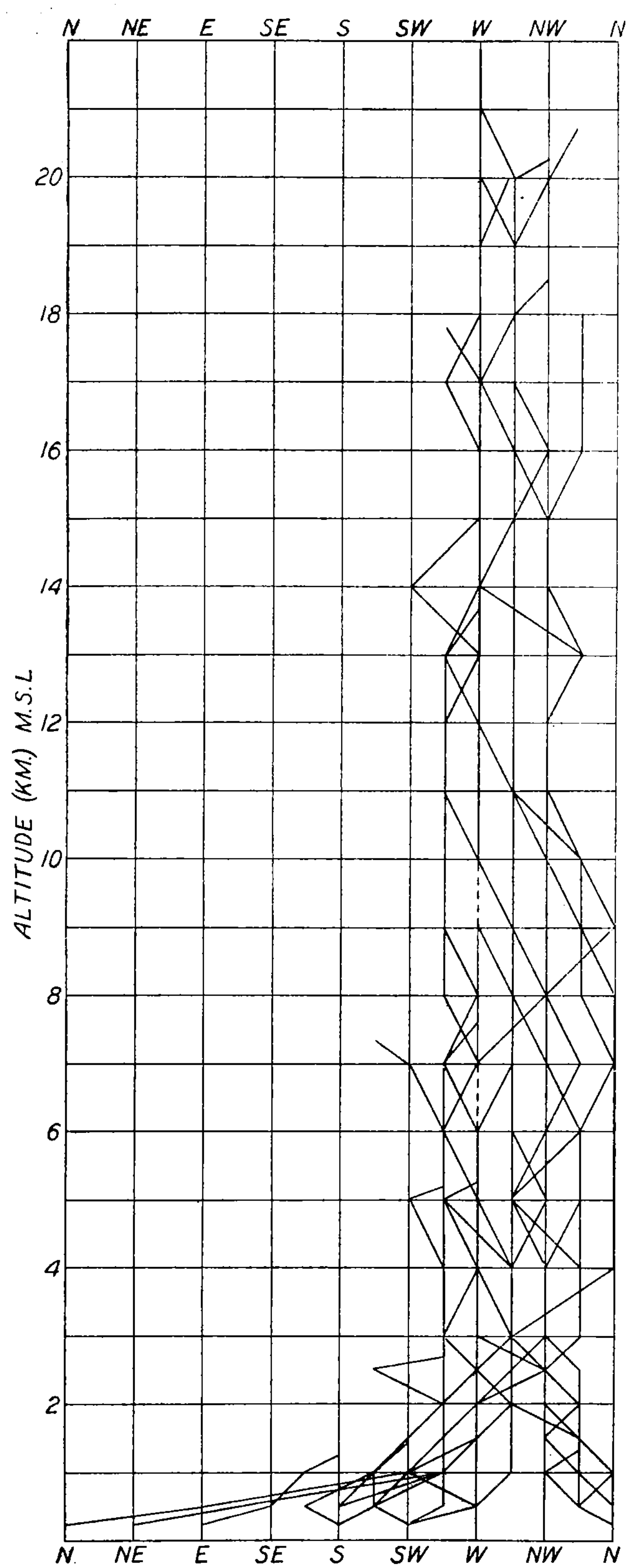

FIGURE 7.—Wind-direction curves for individual observations made at Broken Arrow, Okla., during December, 1929

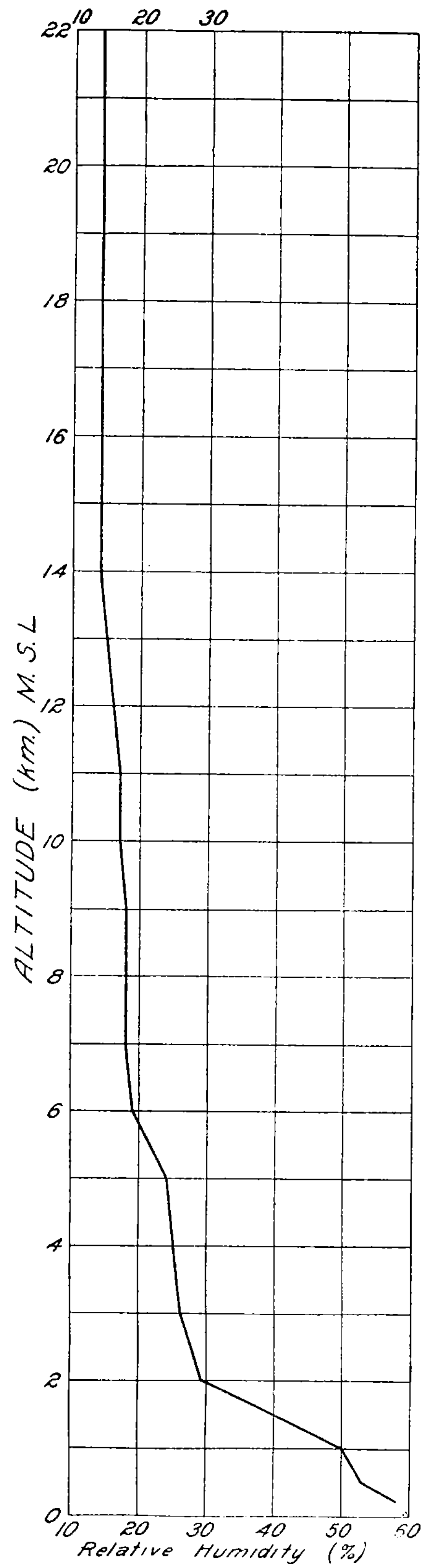

FIGURE 8.—Mean relative humidity curve for December, 1929, Broken Arrow, Okla.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*

DECEMBER 1, 1929

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Humidity		Wind		Remarks
					Relative	Vapor pressure	Direction	Velocity	
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:23	233	991.1	1.4		78	5.27	n.	7.6	1 Ci. Cu. W.; 5 A. Cu., W.; 3 St., N.
	500	958.6	−1.0		85	4.79	n.	10.4	
4:27	943	906.5	−5.0	0.68	96	3.87	n.	15.4	
	1,000	900.0	−4.9		89	3.62	n.	15.6	
4:28	1,065	892.7	−4.7	−0.25	80	3.31	n.	14.3	
4:29	1,327	863.3	−4.8	0.04	93	3.81	nnw.	13.3	
	1,500	844.5	−5.7		90	3.42	nnw.	11.8	
4:31	1,785	814.4	−7.3	0.55	84	2.78	nnw.	11.4	
	2,000	792.2	−6.7		72	2.51	nnw.	14.8	
4:34	2,205	771.6	−5.9	−0.33	61	2.28	nw.	18.1	
	2,500	743.1	−7.5		58	1.89	nw.	16.7	
4:36	2,720	722.4	−8.7	0.54	56	1.64	nw.	11.8	
	3,000	696.9	−9.5		66	1.81	w.	10.2	
4:42	3,825	626.1	−12.0	0.30	97	2.12			
4:43	3,886	621.2	−11.1	−1.48	94	2.24			
	4,000	611.9	−11.8		94	2.10			
4:46	4,602	565.6	−15.3	0.59	94	1.52			
	5,000	537.0	−16.2		76	1.13			
4:49	5,084	530.6	−16.4	0.23	72	1.06			
	6,000	469.9	−24.4		60	0.41			
4:55	6,269	452.3	−26.7	0.87	57	0.31			
	7,000	408.3	−32.0		62	0.19			
5:02	7,816	363.4	−37.9	0.72	68	0.11			
	8,000	354.0	−37.9		61	0.10			
5:03	8,039	352.1	−37.9	0.00	60	0.10			
	9,000	306.2	−43.7		55	0.05			
5:07	9,272	294.5	−45.4	0.61	54	0.04			Tropopause.
5:09	9,604	279.8	−45.4	0.00	51	0.04			
5:10	9,689	276.6	−44.3	−1.29	50	0.04			
	10,000	264.3	−45.3		50	0.03			
	11,000	227.8	−48.5		49	0.02			
	12,000	195.6	−51.7		47	0.02			
5:23	12,327	186.3	−52.7	0.32	47	0.01			

DECEMBER 3, 1929

P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:04	233	994.8	9.8		36	4.36	w.	3.6	Cloudless.
	500	963.2	7.8		37	3.91	w.	6.9	
4:06	586	953.0	7.1	0.76	37	3.73	w.	7.2	
	1,000	906.0	3.8		41	3.29	wnw.	7.2	
4:09	1,171	887.2	2.4	0.80	42	3.05	wnw.	8.9	
4:10	1,345	868.2	3.3	−0.52	40	3.10	wnw.	12.2	
	1,500	852.2	2.8		43	3.21	wnw.	14.2	
4:11	1,560	845.6	2.6	0.33	44	3.24	wnw.	15.2	
	2,000	800.9	2.6		44	3.24	wnw.	16.2	
4:14	2,063	794.5	2.6	0.00	44	3.24	wnw.	16.0	
4:15	2,296	771.9	1.7	0.39	43	2.97	wnw.	17.6	
	2,500	752.7	1.6		41	2.81	wnw.	20.2	
4:17	2,656	738.3	1.5	0.06	40	2.72	wnw.	21.4	
	3,000	707.3	−0.6		39	2.27	wnw.	21.8	
4:19	3,208	689.1	−1.9	0.62	38	1.99	wnw.	22.2	
4:20	3,403	672.6	−1.9	0.00	36	1.88	wnw.	22.2	
	4,000	623.6	−5.1		34	1.36	n.	24.4	
4:25	4,582	578.9	−8.2	0.53	33	1.01	n.	24.8	
	5,000	548.4	−11.5		34	0.78	n.	26.1	
4:31	5,870	489.1	−18.3	0.78	36	0.44	n.	25.5	
	6,000	480.5	−19.4		36	0.40	n.	25.4	
	7,000	419.5	−27.7		36	0.18	n.	28.0	
4:36	7,141	411.3	−28.9	0.83	36	0.16	nnw.	27.3	
	8,000	364.4	−36.3		35	0.07	nnw.	35.2	
4:43	8,847	322.9	−43.5	0.86	35	0.03	nnw.	34.4	
	9,000	315.7	−44.5		35	0.03	nnw.	34.6	
	10,000	272.2	−50.9		34	0.01	nw.	45.8	
4:50	10,639	246.8	−55.0	0.64	34	0.01	nw.	39.4	Tropopause.
4:51	10,998	233.8	−53.9	−0.31	34	0.01	nw.	18.0	
	11,000	233.7	−53.9		34	0.01	nw.	18.0	
	12,000	200.9	−54.5		34	0.01	nw.	23.8	
4:56	12,721	179.8	−55.0	0.06	34	0.01	nnw.	29.4	
	13,000	172.1	−55.6		34	0.01	nnw.	28.0	
	14,000	147.5	−57.8		34	(1)	w.	24.0	
5:02	14,372	139.2	−58.6	0.22	34	(1)	wnw.	24.3	
	15,000	126.1	−60.7		34	(1)	wnw.	29.0	
5:08	15,957	108.2	−64.0	0.34	34	(1)	wnw.	30.1	
	16,000						nw.	30.4	
	17,000						wnw.	22.5	
	18,000						wnw.	21.6	
	19,000						wnw.	16.0	
	20,000						nw.	15.3	
5:26	20,690						nnw.	15.2	

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 4, 1929

Time, 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Humidity		Wind		Remarks
					Relative	Vapor pressure	Direction	Velocity	
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:21	233	995.5	13.4		39	6.00	s.	4.0	Few Ci., WNW.
	500	964.3	11.2		44	5.85	ssw.	7.6	
4:24	851	924.4	8.2	0.84	51	5.54	wsw.	7.1	
	1,000	907.9	9.2		44	5.12	wsw.	8.0	
4:25	1,167	889.8	10.4	−0.70	37	4.67	wsw.	9.4	
	1,500	854.5	8.8				wsw.	10.0	
4:27	1,565	848.0	8.5	0.48			wsw.	9.1	
4:28	1,681	836.1	8.5	0.00			wsw.	7.3	
	2,000	804.3	6.8				w.	4.9	
	2,500	753.4	4.3				nw.	5.4	
4:32	2,548	752.1	4.0	0.52			nw.	5.4	
	3,000	711.1	1.4				wnw.	7.2	
	4,000	627.2	−4.5				wnw.	5.4	
	5,000	552.0	−10.3				nw.	5.6	
4:44	5,171	540.1	−11.3	0.58			nw.	5.9	
	6,000	483.9	−18.1				nw.	8.8	
4:51	6,971	424.7	−26.1	0.82			nw.	10.4	
	7,000	423.2	−26.3				nw.	10.5	
	8,000	367.7	−34.7				nw.	14.2	
	9,000	318.6	−43.1				nw.	15.0	
4:59	9,323	304.1	−45.8	0.84			nw.	14.2	
	10,000	275.1	−51.9				nw.	13.8	
5:02	10,248	264.7	−54.1	0.90			nw.	13.0	
	11,000						nw.	15.8	
	12,000						wnw.	17.4	
	13,000						wnw.	15.1	
	14,000						wnw.	16.9	
	15,000						wnw.	17.0	
	16,000						w.	8.8	
	17,000						wnw.	16.6	
	18,000						wnw.	7.3	
	19,000						wnw.	13.0	
5:40	19,600						wnw.	11.5	

DECEMBER 5, 1929

P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:07	233	985.7	15.7		34	6.07	sw.	7.2	6 Ci., W.; 2 Ci. Cu., W.
	500	955.1	13.9		34	5.40	ssw.	8.1	
4:10	830	918.2	11.7	0.67	35	4.81	ssw.	13.6	
	1,000	899.8	10.6		37	4.73	sw.	14.5	
4:12	1,131	885.8	9.8	0.63	39	4.73	sw.	14.7	
	1,500	847.4	9.6		35	4.18	wsw.	23.3	
	2,000	797.8	9.3		31	3.63	wsw.	21.8	
4:17	2,065	791.4	9.3	0.05	30	3.51	wsw.	21.6	
	2,500	750.9	9.3		26	3.04	w.	18.4	
4:20	2,560	745.5	9.3	0.00	26	3.04	w.	17.8	
	3,000	706.8	5.9		25	2.32	wsw.	15.2	
4:25	3,503	664.5	2.1	0.76	24	1.70	wsw.	15.2	
4:26	3,607	656.0	2.3	−0.19	22	1.59	wsw.	14.7	
	4,000	624.5	−0.7		23	1.33	w.	13.6	
4:34	5,005	549.8	−8.3	0.76	24	0.73	wsw.	23.2	
	6,000	483.1	−16.1		25	0.38			
4:42	6,431	456.6	−19.5	0.79	25	0.28			
	7,000	422.6	−24.3		26	0.18			
4:50	7,949	371.0	−32.3	0.84	27	0.08			
	8,000	368.2	−32.6		27	0.08			
4:52	8,366	350.1	−34.4	0.50	27	0.06			
	9,000	319.6	−40.7		27	0.03			
	10,000	276.1	−50.5		26	0.01			
4:58	10,179	268.6	−52.3	0.99	26	0.01			
5:01	10,759	245.8	−57.6	0.91	25	(1)			

DECEMBER 7, 1929

P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:22	233	984.4	2.6		78	5.74	ne.	2.2	Cloudless.
	500	952.3	0.7		87	5.59	ese.	2.0	
4:26	856	910.9	−1.9	0.72	100	5.23	w.	5.1	
	1,000	894.8	1.1		84	5.55	wsw.	6.8	
4:27	1,119	881.7	3.6	−2.09	70	5.53	w.	7.7	
	1,500	840.7	1.9		65	4.55	w.	7.0	
	2,000	790.0	−0.3		58	3.46	wnw.	7.4	
	2,500	742.4	−2.5		52	2.58	w.	8.5	
4:35	2,844	711.1	−4.0	0.44	47	2.06	wnw.	8.2	
	3,000	697.2	−5.0		47	1.89	wnw.	8.0	
	4,000	612.8	−11.7		46	1.04	w.	16.2	
4:42	4,130	602.6	−12.6	0.67	46	0.96	w.	18.2	
4:43	4,555	570.0	−11.4	−0.28	48	1.11	w.	23.8	
	5,000	537.8	−14.3		45	0.80	w.	23.4	

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 7, 1929—Continued

Time, 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Humidity		Wind		Remarks
					Relative	Vapor pressure	Direction	Velocity	
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:48	5,636	494.4	−18.5	0.66	40	0.48	wsw.	28.4	
	6,000	470.9	−20.8		41	0.40	w.	30.2	
4:52	6,982	411.7	−27.0	0.63	45	0.24	wsw.	28.6	
	7,000	410.8	−27.1		45	0.23	wsw.	28.6	
	8,000	357.3	−34.3		42	0.10	w.	34.1	
4:58	8,784	319.6	−39.9	0.72	40	0.05	wsw.	38.8	
	9,000	309.5	−41.3		40	0.04	wsw.	40.7	
	10,000	267.2	−47.9		39	0.02	wsw.	35.2	
	11,000	229.9	−54.5		38	0.01	wsw.	48.1	
5:07	11,206	222.5	−55.9	0.66	38	0.01	wsw.	49.9	Tropopause.
	12,000	197.4	−55.5		37	0.01	wsw.	39.9	
	13,000	169.0	−54.9		36	0.01	wsw.	54.0	
5:16	13,356	159.9	−54.7	−0.06	35	0.01			
	14,000	149.8	−57.2		35	0.01			
	15,000	123.4	−61.0		34	(1)			
	16,000	105.6	−64.8		33	(1)			
5:37	16,181	102.6	−65.5	0.38	33	(1)			

DECEMBER 8, 1929

Time	Altitude	Pressure	Temperature	Δt/100 m.	Relative	Vapor pressure	Direction	Velocity	Remarks
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
3:39	233	986.2	9.3		70	8.20	se.	5.4	10 Ci., WNW.
	500	955.0	7.8		80	8.46			
3:42	873	912.7	5.6	0.58	95	8.64			
	1,000	898.6	5.7		98	8.98			
3:43	1,067	891.2	5.7	−0.05	100	9.16			
3:45	1,425	853.4	11.4	−1.59	45	6.07			
	1,500	845.8	11.3		43	5.76			
3:47	1,819	814.1	11.1	0.08	35	4.62			
	2,000	796.4	9.9		32	3.90			
	2,500	749.5	6.7		25	2.45			
3:50	2,705	731.1	5.4	0.64	22	1.97			
3:51	2,817	721.2	5.0	0.36	22	1.92			
3:52	2,978	707.4	3.6	0.87	21	1.66			
	3,000	705.5	3.6		21	1.66			
3:53	3,233	685.3	3.8	−0.08	19	1.52			
	4,000	622.9	−1.4		19	1.03			
4:01	4,801	563.0	−6.9	0.68	8	0.62			
	5,000	548.9	−8.1		18	0.56			
	6,000	482.2	−14.0		17	0.31			
4:06	6,126	474.5	−14.7	0.59	17	0.29			
	7,000	422.2	−24.4		16	0.11			
4:11	7,170	412.5	−26.3	1.11	16	0.09			
	8,000	367.3	−32.6		15	0.04			
4:16	8,611	336.9	−37.3	0.76	15	0.03			
	9,000	319.0	−40.2		15	0.02			
4:20	9,900	280.2	−46.8	0.74	15	0.01			

DECEMBER 9, 1929

Time	Altitude	Pressure	Temperature	Δt/100 m.	Relative	Vapor pressure	Direction	Velocity	Remarks
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
3:59	233	988.5	10.7		74	9.52	n.	2.2	10 Ci. St., W.
4:00	465	961.3	8.5	0.95	92	10.21	ne.	2.8	
	500	957.2	8.5		93	10.32	e.	3.8	
4:01	675	937.3	8.4	0.05	98	10.80	ssw.	7.6	
	1,000	901.4	11.6		67	9.15	sw.	12.5	
4:04	1,419	857.5	15.7	−0.98	28	5.00	wsw.	16.4	
	1,500	849.3	15.7		28	5.00	wsw.	16.4	
4:05	1,597	839.9	15.6	0.06	27	4.79	wsw.	16.2	
	2,000	800.4	13.2		26	3.95	wsw.	16.1	
	2,500	754.0	10.1		25	3.09	w.	20.6	
4:10	2,734	733.2	8.7	0.61	24	2.70	w.	21.6	
4:13	2,978	711.9	6.7	0.82	23	2.26	wsw.	20.0	
	3,000	710.0	6.6		23	2.24	wsw.	20.0	
4:16	3,960	630.9	0.8	0.60	31	2.01	w.	16.6	
	4,000	627.8	0.5		31	1.96	w.	17.0	
	5,000	553.5	−6.3		32	1.16	w.	19.8	
4:23	5,783	500.6	−11.6	0.68	33	0.75			

DECEMBER 10, 1929

Time	Altitude	Pressure	Temperature	Δt/100 m.	Relative	Vapor pressure	Direction	Velocity	Remarks
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
3:58	233	988.2	20.6		60	14.57	s.	5.8	4 Ci., WSW.
	500	958.0	18.5		75	15.98	s.	12.2	
4:01	878	916.8	15.6	0.78	96	17.02	ssw.	11.3	
	1,000	903.7	15.1		90	15.45	ssw.	12.5	
4:02	1,005	903.2	15.1	0.39	90	15.45	ssw.	12.6	
4:03	1,106	892.3	15.2	−0.10	55	9.50	sw.	15.2	
4:04	1,294	872.8	17.0	−0.96	40	7.75	sw.	18.0	
	1,500	852.1	16.6		37	6.99	sw.	18.6	
4:07	1,965	806.6	15.6	0.21	30	5.32	wsw.	16.9	
	2,000	803.3	15.4		30	5.25	wsw.	16.8	
	2,500	757.0	12.9		29	4.32	wsw.	15.8	
	3,000	713.2	10.3		28	3.51	w.	12.0	
4:12	3,158	699.8	9.5	0.51	28	3.32	w.	11.5	
	4,000	631.5	2.9		25	1.88	w.	12.6	
	5,000	558.1	−5.0		22	0.89	w.	14.1	

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 10, 1929—Continued

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Humidity		Wind		Remarks
					Relative	Vapor pressure	Direction	Velocity	
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:22	5,430	528.7	−8.4	0.79	20	0.60	wsw.	13.8	
	6,000	490.7	−13.4		20	0.39	wsw.	11.6	
	7,000	429.4	−22.3		19	0.16	w.	8.0	
	8,000	374.3	−31.1		19	0.06	nw.	9.0	
	9,000	324.5	−39.9		18	0.02	wnw.	7.2	
4:37	9,486	302.6	−44.2	0.88	18	0.01	wnw.	8.4	
	10,000	280.1	−49.5		18	0.01	w.	8.8	
	11,000	240.1	−59.7		17	(1)	w.	16.3	
4:45	11,775	212.1	−67.6	1.02	16	(1)	w.	21.9	
	12,000						w.	24.5	
	13,000						wsw.	28.0	
	14,000						w.	32.0	
	15,000						w.	32.0	
	16,000						w.	28.1	
	17,000						w.	24.1	
	18,000						w.	22.2	
	19,000						w.	20.6	
	20,000						wnw.	15.9	
5:19	20,300						nw.	9.0	

DECEMBER 11, 1929

Time	Altitude	Pressure	Temperature	Δt/100 m.	Relative	Vapor pressure	Direction	Velocity	Remarks
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:17	233	984.3	22.8		62	17.22	s.	7.6	3 Ci. St., W.; 6 Ci., W.
	500	954.5	21.0		71	17.66	ssw.	11.2	
	1,000	900.8	17.5		87	17.41	ssw.	13.9	
4:21	1,106	889.8	16.8	0.69	90	17.23	sw.	14.5	
4:22	1,235	876.4	16.4	0.31	88	16.42	sw.	15.1	
4:23	1,440	855.3	15.7	0.34	65	11.60	sw.	16.9	
	1,500	849.4	15.7		61	10.88	sw.	17.4	
4:25	1,918	808.6	16.0	−0.06	36	6.55	wsw.	19.0	
	2,000	800.9	15.4		38	6.65	wsw.	19.4	
4:26	2,238	778.6	13.5	0.78	43	6.66	wsw.	19.6	
	2,500	754.7	11.9		36	5.01	wsw.	17.0	
4:28	2,566	748.7	11.5	0.61	34	4.61	wsw.	16.6	
4:29	2,692	737.5	11.7	−0.16	32	4.40	wsw.	16.2	
	3,000	710.7	9.8		31	3.76	wsw.	14.0	
	4,000	629.5	3.5		28	2.20	w.	12.2	
4:37	4,778	571.9	−1.4	0.63	25	1.36	w.	16.0	
	5,000	556.1	−3.0		25	1.19	w.	16.4	
4:41	5,887	496.8	−9.4	0.72	23	0.63	w.	16.4	
	6,000	489.4	−10.5		23	0.58	w.	15.4	
	7,000	429.4	−20.0		24	0.25	wsw.	11.2	
4:47	7,325	411.3	−23.1	0.95	24	0.18	w.	10.9	
	8,000	375.0	−29.9		25	0.10			
	9,000	326.1	−40.0		27	0.04			
4:54	9,402	307.9	−44.0	1.01	28	0.02			

DECEMBER 13, 1929

Time	Altitude	Pressure	Temperature	Δt/100 m.	Relative	Vapor pressure	Direction	Velocity	Remarks
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:19	233	991.9	20.0		83	19.42	s.	6.7	2 Ci. St., WSW.;
	500	961.7	18.2		92	19.24	ssw.	9.5	8 St., SSW.
4:22	738	935.3	16.6	0.67	100	18.90	ssw.	11.6	
4:23	994	907.6	16.0	0.23	88	16.01	wsw.	10.0	
	1,000	907.0	16.0		88	16.01	wsw.	10.0	
4:24	1,415	863.8	14.6	0.33	99	15.79			
	1,500	855.1	14.5		90	14.86			[1] Lowest temperature recorded; altitude approximately 16,476 m., M. S. L., based on ascensional rate.
4:25	1,589	846.2	14.4	0.11	85	13.95			
	2,000	805.8	11.4		82	11.05			
	2,500	758.8	7.7		79	8.30			
4:30	2,633	746.8	6.7	0.74	78	7.65			
	3,000	714.1	4.5		54	4.55			
4:32	3,031	711.2	4.3	0.60	52	4.32			
4:35	3,705	654.6	2.0	0.34	40	2.82			
	4,000	631.1	0.2		40	2.48			
4:37	4,313	606.9	−1.8	0.62	39	2.06			
	5,000	556.4	−8.7		43	1.26			
4:41	5,028	554.4	−9.0	1.01	43	1.23			
4:42	5,454	524.9	−11.3	0.54	36	0.84			
	6,000	488.8	−16.4		33	0.49			
4:45	6,032	486.5	−16.7	0.93	33	0.47			
	7,000	427.4	−25.5		32	0.19			
4:52	7,457	401.7	−29.7	0.84	31	0.12			
	8,000	372.3	−34.4		30	0.07			
4:57	8,760	334.3	−41.0	0.87	29	0.03			
	9,000	322.7	−43.2		29	0.03			
	10,000	278.5	−52.2		30	0.01			
5:03	10,371	263.2	−55.6	0.91	30	0.01			
	11,000	239.2	−62.1		30	(1)			
5:10	12,000	204.1	−72.5	1.04	31	(1)			Tropopause.
5:13	12,592	185.5	−69.1	−0.57	31	(1)			
5:15	12,958	174.9	−65.9	−0.87	30	(1)			
	13,000	173.5	−66.2		30	(1)			
5:19	13,905	150.3	−73.1	0.76	28	(1)			
	14,000	148.0	−73.7		28	(1)			
	15,000	125.2	−79.2		27	(1)			
5:28	15,191	121.3	−80.8	0.60	27	(1)			
5:30			−81.7[1]						

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 14, 1929

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:25	233	993.7	17.2		95	18.65	s.	3.1	1 A. St., SW.; 9 St., SSW.
	500	963.0	15.9		95	17.17			
	1,000	908.0	13.5		96	14.86			
4:30	1,278	878.4	12.1	0.49	96	13.56			
	1,500	855.3	11.4		73	9.84			
4:31	1,513	854.1	11.4	0.30	72	9.71			
	2,000	805.7	10.0		65	7.98			
4:34	2,108	795.3	9.7	0.29	63	7.58			
4:35	2,463	762.1	7.4	0.65	60	6.18			
	2,500	758.7	7.3		58	5.93			
4:37	2,891	723.4	5.9	0.35	35	3.25			
	3,000	713.8	5.0		34	2.96			
4:39	3,292	688.5	2.7	0.80	33	2.45			
4:40	3,683	656.2	0.3	0.61	65	4.06			
	4,000	630.9	−1.9		75	3.92			
4:44	4,626	582.9	−6.3	0.70	96	3.47			
4:45	4,847	566.9	−7.6	0.59	84	2.71			
	5,000	555.8	−9.0		79	2.26			
4:47	5,214	540.5	−11.0	0.93	72	1.73			
4:49	5,785	502.1	−12.9	0.33	46	0.93			
4:50	5,925	492.8	−14.2	0.93	47	0.85			
	6,000	488.0	−14.8		46	0.78			
4:51	6,394	463.1	−18.1	0.83	43	0.54			
4:52	6,528	455.2	−18.5	0.30	35	0.42			
4:55	6,957	429.8	−23.4	1.14	26	0.20			
	7,000	427.2	−23.7		26	0.19			
	8,000	372.7	−30.6		32	0.12			
4:58	8,260	359.2	−32.4	0.69	34	0.10			
	9,000	323.7	−38.3		36	0.06			
5:03	9,767	289.8	−44.5	0.80	38	0.03			
	10,000	280.1	−46.4		38	0.02			
	11,000	241.5	−54.3		39	0.01			
5:07	11,112	237.2	−55.2	0.80	39	0.01			Tropopause.
	12,000	207.3	−57.3		35	0.01			
5:11	12,316	197.4	−58.0	0.23	34	(1)			
5:13	12,523	191.0	−59.1	0.53	33	(1)			
5:15	12,837	181.8	−58.8	−0.10	33	(1)			
	13,000	177.2	−59.5		33	(1)			
5:18	13,556	162.8	−61.8	0.42	31	(1)			
	14,000	151.7	−65.0		31	(1)			
5:21	14,212	146.8	−66.5	0.72	31	(1)			
	15,000	129.2	−71.1		31	(1)			
5:26	15,144	126.1	−71.9	0.58	31	(1)			
	16,000	109.6	−76.3		30	(1)			
5:32	16,142	106.9	−77.0	0.51	30	(1)			
5:33	16,543	100.3	−76.6	−0.10	30	(1)			
	17,000	93.1	−74.7		31	(1)			
5:42	17,324	88.2	−73.4	−0.41	31	(1)			

DECEMBER 16, 1929

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:12	233	985.9	16.6		76	14.36	s.	4.5	4 St. Cu., SSW., at 4:12 p. m., increasing to 9 St. Cu., SSW., by 4:20 p. m.
	500	955.3	14.4		85	13.95	sse.	4.5	
4:17	952	905.3	10.6	0.83	100	12.78	ssw.	4.5	
	1,000	900.1	10.5		97	12.32	ssw.	4.5	
4:18	1,194	879.5	9.9	0.29	85	10.37	ssw.	4.4	
	1,500	847.6	8.0		93	9.98	sw.	5.7	
4:21	1,742	823.2	6.5	0.62	100	9.68	wsw.	6.0	
4:22	1,898	807.6	6.1	0.26	66	6.21	wsw.	5.8	
	2,000	797.6	6.3		60	5.72	wsw.	5.4	
4:23	2,163	782.0	6.5	−0.15	51	4.94	wsw.	5.0	
	2,500	750.5	5.1		44	3.86	ssw.	4.7	
4:25	2,592	741.9	4.7	0.42	42	3.59	wsw.	4.5	
4:27	2,868	717.3	2.7	0.72	46	3.41			
	3,000	705.7	1.8		44	3.06			
4:32	4,003	622.4	−4.8	0.66	32	1.31			
4:36	4,937	552.3	−11.6	0.73	34	0.77			
	5,000	547.7	−11.8		34	0.76			
4:39	5,622	505.2	−13.8	0.32	30	0.56			
	6,000	479.7	−15.2		29	0.48			
	7,000	420.2	−18.7		28	0.33			
	8,000	367.6	−22.4		26	0.22			
4:44	8,430	347.3	−23.9	0.36	25	0.18			
	9,000	321.0	−26.7		25	0.13			
	10,000	280.3	−31.7		24	0.08			
4:49	10,165	273.5	−32.5	0.50	24	0.07			
4:51	10,528	259.9	−35.3	0.77	25	0.05			
4:52	10,764	251.4	−37.3	0.85	24	0.04			

DECEMBER 17, 1929

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
A. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
7:27	233	982.2	13.0		98	14.68	e.	2.7	9 St. Cu., Sw.; 10 light haze.
	500	951.5	12.4		95	13.68	se.	4.8	
7:30	924	904.7	11.4	0.23	91	12.27	sse.	2.5	
	1,000	896.2	11.0		92	12.08	sse.	2.4	

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 17, 1929—Continued

Time 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
A. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
7:32	1,399	854.5	9.1	0.49	100	11.56			
	1,500	843.9	8.6		96	10.72			
7:35	1,946	800.0	6.4	0.50	79	7.59			
	2,000	794.3	5.9		80	7.42			
	2,500	747.1	1.9		91	6.37			
7:38	2,702	728.7	0.3	0.80	96	5.99			
	3,000	701.9	−1.3		74	4.06			
7:41	3,391	668.7	−3.4	0.54	46	2.12			
	4,000	618.7	−7.8		44	1.39			
7:47	4,711	564.4	−12.9	0.72	41	0.83			
	5,000	543.7	−14.1		38	0.69			
7:51	5,669	498.1	−17.0	0.43	30	0.42			
	6,000	476.5	−20.7		34	0.33			
7:55	6,656	435.7	−28.0	1.11	41	0.19			
	7,000	415.7	−30.2		42	0.16			
	8,000	361.3	−36.7		45	0.08			
8:01	8,380	342.2	−39.1	0.64	46	0.06			
	9,000	312.9	−43.4		46	0.04			
	10,000	269.9	−50.4		45	0.02			
	11,000	231.9	−57.3		44	0.01			
8:10	11,072	229.3	−57.8	0.69	44	0.01			Tropopause.
	12,000	199.4	−56.8		42	0.01			
	13,000	170.9	−55.8		40	0.01			
	14,000	146.0	−54.7		38	0.01			
8:18	14,019	145.6	−54.7	−0.11	38	0.01			
	15,000	125.1	−56.9		37	0.01			
	16,000	107.3	−59.1		37	(1)			
8:28	16,706	95.9	−60.7	0.22	36	(1)			
	17,000	91.8	−60.3		36	(1)			
	18,000	78.6	−59.0		36	(1)			
8:38	18,962	67.5	−57.8	−0.13	36	(1)			

DECEMBER 18, 1929

Time 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:45	233	999.0	−8.4		70	2.11	n.	13.4	6 A. Cu., NW.; 4 St., NNW.
	500	965.0	−10.4				nnw.	16.7	
4:48	903	915.5	−13.4	0.75			nw.	19.1	
	1,000	904.0	−12.9				nw.	18.9	
4:49	1,185	882.3	−12.0	−0.50			nnw.	18.2	
	1,500	846.6	−13.4						
	2,000	792.5	−15.7						
4:53	2,010	791.4	−15.7	0.45					
4:54	2,246	767.2	−16.0	0.13					
	2,500	741.8	−17.3						
	3,000	693.6	−19.9						
4:59	3,249	670.7	−21.2	0.52					
5:00	3,505	647.8	−22.6	0.55					
	4,000	605.5	−24.6						
5:04	4,542	562.0	−26.7	0.40					
	5,000	527.3	−30.3						
5:06	5,071	522.3	−30.9	0.79					
	6,000	457.7	−36.6						
5:12	6,874	403.1	−42.0	0.62					

DECEMBER 19, 1929

Time 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:10	233	996.5	−6.0		45	1.66	nw.	4.9	Cloudless.
	500	962.9	−8.4		47	1.41	nw.	6.6	
4:14	762	930.9	−10.7	0.89	48	1.18	nw.	6.6	
	1,000	902.2	−13.1		51	1.01	nw.	7.2	
4:18	1,464	848.2	−17.8	1.01	56	0.72	nw.	10.1	
	1,500	844.1	−17.6		55	0.72	nw.	10.4	
4:19	1,646	827.9	−17.0	−0.44	50	0.70	nnw.	12.4	
4:20	1,848	806.1	−16.8	−0.10	44	0.62	nnw.	13.2	
	2,000	789.7	−17.2		47	0.64	nnw.	13.6	
4:21	2,157	773.4	−17.6	0.26	51	0.67	nnw.	13.9	
4:23	2,456	743.3	−17.8	0.07	51	0.66	nw.	14.0	
	2,500	738.8	−18.0		51	0.64	nw.	14.3	
	3,000	690.8	−20.1		56	0.58	nw.	18.0	
4:26	3,008	690.2	−20.1	0.42	56	0.58	nw.	18.3	
4:28	3,355	658.6	−20.7	0.17	57	0.56	nw.	21.2	
4:29	3,629	634.5	−20.7	0.00	52	0.51	nw.	20.8	
4:30	3,744	624.5	−21.5	0.70	51	0.46	nw.	24.6	
	4,000	603.3	−21.7		49	0.44	nw.	21.9	
4:35	4,478	565.1	−22.1	0.08	45	0.38	nw.	33.0	
	5,000	526.3	−25.3		43	0.27	nw.	32.2	
4:40	5,624	483.0	−29.1	0.61	40	0.17	nw.	32.5	
	6,000	457.7	−32.4		39	0.12	nw.	32.0	
4:45	6,538	423.4	−37.2	0.89	38	0.07	nw.	31.7	
	7,000	396.8	−39.1		37	0.05	nw.	37.8	
4:49	7,417	374.1	−40.9	0.42	37	0.04	nw.	38.3	
	8,000	343.2	−44.3		37	0.03	nw.	36.0	
4:56	8,999	295.3	−50.1	0.58	37	0.01	nw.	40.6	Tropopause.
5:00	9,993	253.8	−50.1	0.00	36	0.01	nw.	44.6	
	10,000	253.6	−50.1		36	0.01	nw.	44.6	

[1] Less than 0.01 mb.

Table 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 19, 1929—Continued

Time 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	Δt/100 m.	Humidity		Wind		Remarks
					Relative	Vapor pressure	Direction	Velocity	
P.m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.p.s.*	
5:01	10,401	238.6	−49.9	−0.05	36	0.01	-------	-------	
	11,000	217.9	−50.5	-------	36	0.01	-------	-------	
5:07	11,806	193.0	−51.3	0.10	36	0.01	-------	-------	
	12,000	187.1	−52.5	-------	36	0.01	-------	-------	
5:14	12,515	172.5	−55.8	0.63	35	0.01	-------	-------	
	13,000	160.3	−55.8	-------	35	0.01	-------	-------	
5:19	13,353	151.8	−55.8	0.00	35	0.01	-------	-------	
5:21	13,766	142.4	−58.3	0.61	35	(1)	-------	-------	
	14,000	137.4	−59.1	-------	35	(1)	-------	-------	
5:25	14,355	130.0	−60.3	0.34	34	(1)	-------	-------	
	15,000	117.6	−60.4	-------	34	(1)	-------	-------	
	16,000	100.7	−60.5	-------	34	(1)	-------	-------	
	17,000	85.9	−60.5	-------	34	(1)	-------	-------	
	18,000	73.3	−60.6	-------	34	(1)	-------	-------	
5:48	18,704	65.3	−60.7	0.01	34	(1)	-------	-------	

DECEMBER 20, 1929

Time 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	Δt/100 m.	Relative	Vapor pressure	Direction	Velocity	Remarks
P. m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.p.s.*	
4:01	233	999.9	1.0	-------	49	3.21	w.	2.0	1 Ci., WSW.
	500	967.0	−1.9	-------	49	2.56	w.	4.9	
4:04	849	925.3	−5.6	1.07	49	1.88	wnw.	5.6	
	1,000	907.6	−7.1	-------	50	1.68	wnw.	6.2	
	1,500	850.6	−12.2	-------	52	1.12	wnw.	7.5	
4:08	1,620	837.5	−13.4	1.01	53	1.02	wnw.	9.4	
	2,000	796.6	−12.9	-------	56	1.13	wnw.	12.2	
4:10	2,034	793.1	−12.9	−0.12	57	1.15	wnw.	12.0	
4:11	2,317	764.2	−13.8	0.32	57	1.06	wnw.	12.0	
4:12	2,479	748.2	−13.3	−0.31	54	1.05	wnw.	12.5	
	2,500	746.1	−13.4	-------	54	1.04	wnw.	12.6	
	3,000	698.5	−16.1	-------	51	0.77	wnw.	12.2	
4:16	3,443	658.3	−18.5	0.54	49	0.59	wnw.	15.1	
4:17	3,676	638.4	−17.3	−0.52	45	0.61	wnw.	16.0	
	4,000	611.1	−18.9	-------	49	0.57	wnw.	9.8	
4:23	4,939	538.1	−23.7	0.51	59	0.43	w.	20.9	
	5,000	533.8	−24.1	-------	59	0.41	w.	21.2	
	6,000	465.0	−30.0	-------	57	0.22	w.	28.0	
4:30	6,478	434.9	−32.8	0.59	56	0.16	w.	38.2	
	7,000	403.7	−36.0	-------	53	0.11	w.	38.5	
	8,000	349.2	−42.2	-------	48	0.05	wsw.	44.8	
4:37	8,652	317.3	−46.2	0.62	45	0.03	wsw.	46.5	Tropopause.
4:38	8,880	306.8	−45.5	−0.31	44	0.03	wsw.	45.9	
	9,000	301.4	−45.7	-------	44	0.03	wsw.	44.8	
	10,000	260.3	−47.1	-------	44	0.02	wsw.	51.6	
	11,000	224.2	−48.6	-------	43	0.02	wsw.	49.3	
	12,000	192.7	−50.1	-------	43	0.02	wsw.	48.0	
4:49	12,087	189.7	−50.7	0.16	43	0.02	wsw.	48.8	
	13,000	165.2	−52.0	-------	43	0.01	w.	42.2	
	14,000	141.7	−53.3	-------	43	0.01	w.	25.6	
	15,000	121.5	−54.7	-------	43	0.01	w.	21.2	
	16,000	104.0	−56.1	-------	43	0.01	w.	28.9	
5:01	16,861	90.7	−57.8	0.14	43	0.01	w.	19.8	
	17,000	88.6	−57.5	-------	43	0.01	w.	18.7	
	18,000	75.8	−59.3	-------	43	(1)	w.	17.3	
5:09	18,927	65.7	−60.9	0.17	43	(1)	w.	7.1	
	19,000	64.8	−60.8	-------	43	(1)	w.	6.8	
	20,000	55.5	−59.1	-------	42	(1)	-------	-------	
5:24	20,355	52.3	−58.5	−0.17	42	0.01	-------	-------	

DECEMBER 21, 1929

Time 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	Δt/100 m.	Relative	Vapor pressure	Direction	Velocity	Remarks
P. m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.p.s.*	
4:26	233	1,004.7	−2.5	-------	52	2.58	n.	3.6	4 Ci., SSW.; 5 Ci. St., SW.
	500	971.2	−4.8	-------	53	2.17	nnw.	6.3	
4:29	873	926.1	−8.1	0.88	55	1.70	nnw.	5.7	
	1,000	911.1	−8.0	-------	53	1.65	nnw.	5.5	
4:30	1,404	864.8	−7.7	−0.08	47	1.50	nnw.	4.7	
	1,500	854.3	−8.1	-------	47	1.45	nnw.	4.9	
	2,000	800.9	−10.1	-------	46	1.20	nnw.	5.8	
4:33	2,391	761.3	−11.6	0.40	45	1.02	nw.	4.7	
	2,500	750.5	−12.2	-------	44	0.95	nw.	4.9	
	3,000	702.7	−14.7	-------	42	0.72	wnw.	7.6	
4:37	3,389	667.4	−16.7	0.50	40	0.57	wnw.	8.9	
	4,000	615.3	−19.5	-------	40	0.44	wnw.	7.4	
4:39	4,184	600.4	−20.3	0.45	40	0.40	w.	7.5	
	5,000	537.5	−23.5	-------	40	0.30	wsw.	16.4	
4:41	5,096	530.4	−23.9	0.39	40	0.29	wsw.	17.7	
	6,000	468.0	−31.2	-------	40	0.14	wsw.	23.7	
4:46	6,613	429.2	−36.1	0.80	40	0.08	sw.	30.2	
	7,000	405.7	−39.9	-------	40	0.05	sw.	29.4	
4:50	7,728	364.8	−47.1	0.90	40	0.02	-------	-------	Tropopause.
4:51	7,999	350.5	−46.3	−0.30	40	0.02	-------	-------	
	9,000	301.7	−49.6	-------	39	0.02	-------	-------	
4:55	9,597	275.7	−51.5	0.32	38	0.01	-------	-------	
	10,000	259.6	−51.0	-------	38	0.01	-------	-------	
4:58	10,705	233.2	−50.1	−0.13	38	0.01	-------	-------	
	11,000	222.7	−50.8	-------	38	0.01	-------	-------	
	12,000	191.5	−53.0	-------	38	0.01	-------	-------	
	13,000	164.0	−55.3	-------	38	0.01	-------	-------	

[1] Less than 0.01 mb.

Table 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 21, 1929—Continued

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	Δt/100 m.	Humidity		Wind		Remarks
					Relative	Vapor pressure	Direction	Velocity	
P.m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.p.s.*	
5:06	13,108	161.2	−55.5	0.22	38	0.01	-------	-------	
5:07	13,199	158.8	−54.5	−1.00	38	0.01	-------	-------	
	14,000	140.5	−55.4	-------	38	0.01	-------	-------	
5:10	14,072	138.7	−55.5	0.11	38	0.01	-------	-------	
	15,000	120.0	−60.4	-------	38	(1)	-------	-------	
5:16	15,294	114.5	−62.0	0.53	38	(1)	-------	-------	
	16,000	102.3	−62.3	-------	38	(1)	-------	-------	
5:19	16,334	97.0	−62.5	0.05	38	(1)	-------	-------	

DECEMBER 22, 1929

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	Δt/100 m.	Relative	Vapor pressure	Direction	Velocity	Remarks
P. m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.p.s.*	
3:32	233	998.4	−0.7	-------	44	2.54	n.	3.1	Cloudless.
	500	966.1	−3.5	-------	-----	------	n.	4.6	
	1,000	904.3	−8.9	-------	-----	------	n.	6.2	
3:36	1,192	882.2	−10.9	1.06	-----	------	n.	6.4	
	1,500	848.7	−11.3	-------	-----	------	nnw.	9.0	
3:38	1,551	841.9	−11.4	0.14	-----	------	nnw.	9.0	
	2,000	794.5	−13.7	-------	-----	------	wnw.	10.4	
3:42	2,448	748.2	−16.0	0.51	-----	------	wnw.	10.6	
	2,500	743.5	−16.3	-------	-----	------	wnw.	10.4	
	3,000	693.7	−19.5	-------	-----	------	wnw.	11.3	
3:48	3,883	614.7	−25.1	0.63	-----	------	wnw.	13.3	
	4,000	605.4	−25.9	-------	-----	------	wnw.	14.0	
	5,000	526.8	−32.8	-------	-----	------	wnw.	29.0	
3:55	5,558	484.2	−36.6	0.70	-----	------	wnw.	35.0	
	6,000	457.3	−38.2	-------	-----	------	wnw.	34.9	
	7,000	395.8	−41.7	-------	-----	------	wnw.	42.6	
4:00	7,039	390.2	−41.8	0.35	-----	------	wnw.	42.6	
	8,000	341.2	−46.8	-------	-----	------	wnw.	39.6	
	9,000	293.6	−52.1	-------	-----	------	w.	34.4	
4:10	9,386	273.5	−54.1	0.52	-----	------	w.	35.0	Tropopause.
	10,000	251.4	−54.0	-------	-----	------	w.	27.6	
	11,000	215.4	−53.9	-------	-----	------	w.	36.3	
	12,000	185.3	−53.7	-------	-----	------	w.	29.5	
4:20	12,066	180.3	−53.7	−0.01	-----	------	w.	28.0	
	13,000	159.5	−56.0	-------	-----	------	wsw.	28.2	
	14,000	137.2	−58.4	-------	-----	------	-------	-------	
	15,000	117.3	−60.9	-------	-----	------	-------	-------	
4:37	15,780	100.1	−62.8	0.25	-----	------	-------	-------	

DECEMBER 23, 1929

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	Δt/100 m.	Relative	Vapor pressure	Direction	Velocity	Remarks
P. m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.p.s.*	
4:12	233	994.4	5.0	-------	48	4.19	sw.	4.9	Cloudless.
	500	962.1	2.9	-------	-----	------	ssw.	8.0	
	1,000	904.1	−1.0	-------	-----	------	sw.	7.9	
4:16	1,079	895.2	−1.6	0.78	-----	------	sw.	7.8	
4:18	1,423	857.3	−2.3	0.20	-----	------	wsw.	11.7	
	1,500	849.0	−2.6	-------	-----	------	w.	11.8	
4:20	1,872	809.9	−4.3	0.45	-----	------	w.	8.4	
	2,000	796.9	−4.3	-------	-----	------	w.	7.9	
4:21	2,146	782.3	−4.2	−0.04	-----	------	w.	7.9	
	2,500	747.7	−6.0	-------	-----	------	wnw.	11.2	
	3,000	701.2	−8.6	-------	-----	------	nw.	12.9	
4:27	3,313	673.5	−10.2	0.51	-----	------	nw.	14.5	
	4,000	615.7	−14.4	-------	-----	------	nw.	16.5	
4:31	4,234	597.0	−15.8	0.61	-----	------	nw.	16.0	
	5,000	539.5	−18.5	-------	-----	------	nnw.	23.7	
4:36	5,269	520.2	−19.4	0.35	-----	------	nnw.	23.0	
	6,000	470.9	−24.7	-------	-----	------	nnw.	30.7	
4:41	6,634	431.6	−29.3	0.73	-----	------	nnw.	34.8	
	7,000	410.0	−32.1	-------	-----	------	n.	35.7	
	8,000	355.5	−39.9	-------	-----	------	n.	37.1	
4:49	8,729	319.7	−45.5	0.77	-----	------	nnw.	36.2	
	9,000	306.8	−48.3	-------	-----	------	nnw.	42.2	
4:56	9,820	271.1	−56.8	1.04	-----	------	nnw.	43.8	Tropopause.
	10,000	263.8	−56.8	-------	-----	------	nnw.	42.6	
4:57	10,419	247.0	−56.8	0.00	-----	------	nnw.	35.9	
	11,000	225.9	−59.8	-------	-----	------	nnw.	28.7	
5:00	11,176	219.8	−60.7	0.52	-----	------	nw.	28.5	
5:04	11,822	198.6	−54.0	−1.04	-----	------	wnw.	24.4	
	12,000	193.4	−54.0	-------	-----	------	wnw.	19.2	
	13,000	166.4	−54.3	-------	-----	------	w.	33.3	
	14,000	142.4	−54.5	-------	-----	------	w.	24.8	
	15,000	122.0	−54.8	-------	-----	------	w.	27.8	
	15,558	111.6	−54.9	0.02	-----	------	w.	24.4	
	16,000	104.5	−55.4	-------	-----	------	w.	24.3	
	17,000	89.7	−56.5	-------	-----	------	w.	27.3	
	18,000	76.8	−57.7	-------	-----	------	wnw.	18.4	
	19,000	65.7	−58.8	-------	-----	------	wnw.	19.5	
	20,000	55.9	−59.9	-------	-----	------	w.	22.0	
	21,000	47.6	−61.1	-------	-----	------	w.	22.3	
	21,289	45.5	−61.4	0.11	-----	------	w.	17.8	

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 24, 1929

Time 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Humidity		Wind		Remarks
					Relative	Vapor pressure	Direction	Velocity	
P. m.	*M.*	*Mb.*	*°C.*		*P. ct.*	*Mb.*		*M.p.s.*	
4:04	233	991.3	11.8	------	45	6.23	w.	3.6	Cloudless.
	500	960.0	10.2	------	46	5.72	w.	6.2	
4:06	923	912.2	7.6	0.61	48	5.01	wnw.	8.4	
	1,000	903.7	7.9	------	48	5.11	nw.	9.3	
4:07	1,063	896.9	8.1	−0.36	48	5.18	nw.	10.0	
	1,500	850.1	4.5	------	49	4.13	nw.	14.1	
	2,000	799.1	0.3	------	49	3.06	nw.	15.7	
4:13	2,454	754.8	−3.5	0.83	50	2.29	nw.	14.2	
	2,500	750.6	−3.8	------	50	2.23	nw.	14.3	
	3,000	704.4	−7.2	------	49	1.64	nw.	17.3	
	4,000	618.8	−13.9	------	46	0.85	nw.	22.6	
4:18	4,085	611.9	−14.5	0.67	46	0.80	nw.	24.4	
4:19	4,399	586.9	−15.2	0.22	45	0.74	nw.	27.4	
	5,000	541.8	−18.8	------	45	0.53	nw.	28.7	
4:22	5,327	518.8	−20.8	0.60	45	0.44	nnw.	29.7	
	6,000	473.4	−24.7	------	42	0.28	nnw.	44.4	
4:26	6,457	444.8	−27.4	0.58	40	0.20	nnw.	45.1	
4:27	6,570	438.0	−27.8	0.35	39	0.19	nnw.	45.3	
	7,000	412.5	−31.4	------	37	0.12	n.	50.7	
4:31	7,694	374.0	−37.3	0.85	35	0.06	n.	50.8	
	8,000	------	------	------	------	------	nnw.	52.0	
	9,000	------	------	------	------	------	nnw.	44.8	
	10,000	------	------	------	------	------	nnw.	28.4	
	10,609	------	------	------	------	------	wnw.	25.0	
	11,000	------	------	------	------	------	wnw.	34.9	
	12,000	------	------	------	------	------	wnw.	24.9	
	13,000	------	------	------	------	------	wnw.	20.0	
	13,070	------	------	------	------	------	wnw.	20.0	

DECEMBER 25, 1929

Time 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Humidity		Wind		Remarks
					Relative	Vapor pressure	Direction	Velocity	
P. m.	*M.*	*Mb.*	*°C.*		*P. ct.*	*Mb.*		*M.p.s.*	
3:49	233	989.0	16.6	------	28	5.29	sw.	6.7	Cloudless.
	500	958.2	15.0	------	31	5.29	ssw.	12.3	
	1,000	903.0	11.9	------	37	5.15	wsw.	16.5	
3:53	1,211	880.4	10.6	0.61	39	4.98	wsw.	17.5	
3:54	1,402	860.7	12.6	−1.05	36	5.25	w.	18.0	
3:54½	1,500	850.6	11.5	1.12	35	4.75	w.	17.0	
	2,000	800.9	8.9	------	36	4.10	w.	13.3	
	2,500	753.7	6.3	------	37	3.53	w.	13.1	
3:58	2,619	743.0	5.7	0.52	37	3.39	w.	13.5	
	3,000	709.1	2.8	------	36	2.69	wnw.	15.2	
4:02	3,559	661.7	−1.4	0.76	35	1.90	nw.	14.4	
	4,000	625.7	−4.6	------	35	1.46	wnw.	16.9	
4:06	4,528	585.0	−8.4	0.72	35	1.05	nw.	17.7	
	5,000	550.7	−11.2	------	36	0.85	nw.	17.9	
4:08	5,158	539.4	−12.1	0.59	36	0.78	wnw.	18.7	
	6,000	482.6	−18.0	------	24	0.30	nw.	19.5	
4:13	6,186	470.9	−19.3	0.70	21	0.24	nw.	19.4	
	7,000	421.9	−25.0	------	21	0.13	nw.	19.9	
4:16	7,165	412.5	−26.2	0.70	21	0.12	nw.	20.7	
	8,000	367.2	−33.7	------	21	0.05	nw.	24.1	
4:21	8,427	345.5	−37.6	0.90	21	0.04	nw.	23.6	
4:23	8,893	323.6	−40.8	0.69	21	0.02	wnw.	23.7	
	9,000	318.4	−41.5	------	21	0.02	nw.	23.8	
4:24	9,235	307.8	−43.1	0.67	20	0.02	nw.	26.3	
	10,000	274.8	−48.5	------	20	0.01	nw.	25.1	
	11,000	236.4	−55.6	------	20	[1]	nw.	21.6	
4:31	11,564	216.9	−59.6	0.71	20	[1]	nw.	24.7	
	12,000	202.8	−62.4	------	20	[1]	nw.	21.6	Tropopause.
4:34	12,212	196.1	−63.8	0.65	20	[1]	nw.	23.1	
	13,000	173.4	−59.7	------	20	[1]	nw.	21.3	
4:38	13,204	168.0	−58.7	−0.51	20	[1]	wnw.	20.0	
4:39	13,444	161.6	−58.4	−0.12	20	[1]	wnw.	23.1	
4:40	13,706	155.3	−58.7	0.11	20	[1]	nw.	26.4	
[illegible]	14,000	148.2	−59.3	------	20	[1]	nw.	26.7	
4:42	14,409	139.2	−60.1	0.20	20	[1]	nw.	23.9	
4:44	14,642	133.9	−60.5	0.17	19	[1]	nw.	24.8	
	15,000	126.9	−59.9	------	19	[1]	nw.	18.5	
4:45	15,036	126.2	−59.8	−0.18	19	[1]	nw.	18.2	
	16,000	108.5	−61.4	------	19	[1]	wnw.	16.4	
	17,000	92.4	−63.2	------	19	[1]	w.	11.0	
4:53	17,087	91.0	−63.3	0.17	19	[1]	w.	12.4	
	18,000	78.9	−62.7	------	18	[1]	wnw.	8.5	
5:01	18,866	68.7	−62.1	−0.07	18	[1]	wnw.	12.0	
	19,000	67.2	−61.9	------	18	[1]	wnw.	12.1	
	20,000	57.5	−60.2	------	18	[1]	wnw.	10.9	
5:10	20,988	49.2	−58.6	−0.16	18	[1]	w.	6.4	
	21,000	49.1	−58.6	------	18	[1]	w.	6.4	
	22,000	42.1	−56.7	------	18	[1]	------	------	
5:17	22,921	36.4	−54.9	−0.19	18	[1]	------	------	

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 27, 1929

Time 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Humidity		Wind		Remarks
					Relative	Vapor pressure	Direction	Velocity	
P. m.	*M.*	*Mb.*	*°C.*		*P. ct.*	*Mb.*		*M.p.s.*	
4:21	233	992.3	9.4	------	49	5.78	n.	3.8	Cloudless.
	500	960.6	7.3	------	47	4.80	nnw.	6.0	
4:24	896	915.3	4.3	0.77	45	3.74	nnw.	8.9	
	1,000	903.7	4.2	------	44	3.63	n.	10.0	
4:25	1,195	882.3	4.1	0.07	41	3.36	n.	10.4	
	1,500	849.6	2.7	------	41	3.04	nnw.	9.8	
	2,000	798.6	0.5	------	40	2.53	nw.	11.0	
	2,500	750.2	−1.7	------	39	2.07	nw.	10.2	
4:31	2,623	738.6	−2.3	0.04	39	1.97	nw.	9.9	
4:33	2,928	710.9	−3.2	0.30	39	1.83	wnw.	10.5	
	3,000	704.1	−3.7	------	39	1.76	wnw.	10.9	
	4,000	614.4	−10.5	------	41	1.03	wnw.	14.7	
4:38	4,154	601.2	−11.5	0.68	41	0.94	wnw.	15.4	
	5,000	541.7	−18.1	------	38	0.48	wnw.	11.3	
4:43	5,267	524.4	−20.2	0.78	37	0.38	wnw.	10.5	
4:45	5,790	489.0	−21.7	0.29	39	0.35	wnw.	14.8	
	6,000	475.1	−23.2	------	38	0.29	wnw.	16.0	
	7,000	414.0	−30.5	------	36	0.13	nw.	20.2	
4:52	7,451	388.4	−33.8	0.73	35	0.09	nw.	22.8	
	8,000	359.4	−38.2	------	36	0.06	wnw.	25.2	
	9,000	310.4	−46.2	------	38	0.02	w.	26.9	
5:00	9,660	281.4	−51.5	0.80	39	0.01	w.	27.9	Tropopause.
	10,000	267.8	−51.7	------	39	0.01	w.	33.1	
	11,000	230.6	−52.2	------	39	0.01	w.	36.9	
	12,000	197.9	−52.8	------	39	0.01	w.	33.3	
5:09	12,805	174.6	−53.2	0.05	39	0.01	w.	35.8	
	13,000	169.7	−53.6	------	------	------	wsw.	36.0	
	14,000	145.6	−55.7	------	------	------	w.	33.7	
	15,000	124.4	−57.8	------	------	------	w.	28.8	
5:17	15,938	107.4	−59.8	0.21	------	------	w.	27.6	
	16,000	106.2	−60.0	------	------	------	w.	27.3	
	17,000	90.7	−63.7	------	------	------	wsw.	21.0	
	18,000	77.3	−67.4	------	------	------	w.	15.0	
	19,000	65.5	−71.0	------	------	------	------	------	
5:29	19,078	64.8	−71.3	0.37	------	------	------	------	

DECEMBER 28, 1929

Time 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Humidity		Wind		Remarks
					Relative	Vapor pressure	Direction	Velocity	
P. m.	*M.*	*Mb.*	*°C.*		*P. ct.*	*Mb.*		*M.p.s.*	
4:22	233	995.6	9.8	------	32	3.88	n.	6.7	Cloudless.
	500	964.0	7.9	------	32	3.41	n.	10.4	
4:26	935	914.1	4.8	0.71	32	2.75	nnw.	10.2	
	1,000	907.0	4.3	------	32	2.66	nnw.	10.4	
	1,500	852.4	0.4	------	30	2.58	nw.	15.0	
4:29	1,596	842.3	−0.4	0.79	30	1.77	nw.	16.2	
4:30	1,759	825.3	−1.3	0.55	25	1.37	nw.	17.2	
	2,000	800.7	−2.8	------	26	1.26	nw.	19.3	
	2,500	751.6	−5.9	------	30	1.12	nw.	26.2	
4:35	2,906	713.4	−8.4	0.62	32	0.96	nw.	28.5	
	3,000	704.8	−8.4	------	32	0.96	nw.	30.0	
4:38	3,386	670.7	−8.4	0.00	34	1.02	nw.	33.5	
	4,000	620.5	−14.0	------	37	0.68	nw.	39.1	
4:42	4,096	613.2	−14.9	0.92	37	0.63	nw.	37.8	
4:44	4,376	591.5	−13.6	−0.46	34	0.65	wnw.	34.4	
	5,000	544.5	−18.6	------	34	0.40	nw.	33.4	
4:50	5,831	486.6	−25.3	0.80	35	0.22	wnw.	38.8	
	6,000	475.5	−26.6	------	35	0.19	wnw.	34.0	
	7,000	413.5	−34.5	------	35	0.08	wnw.	35.0	
4:55	7,222	400.7	−36.2	0.78	35	0.07	wnw.	39.2	
4:56	7,430	388.8	−37.3	0.53	33	0.06	wnw.	41.2	
	8,000	358.2	−41.0	------	32	0.04	wnw.	40.8	
5:01	8,480	334.1	−44.2	0.66	32	0.02	w.	46.3	
5:02	8,600	328.0	−43.3	−0.75	32	0.03	w.	48.0	
	9,000	309.5	−46.5	------	31	0.02	w.	47.8	
5:07	9,807	274.2	−53.0	0.80	28	0.01	w.	53.9	Tropopause.
	10,000	266.4	−52.2	------	30	0.01	w.	47.4	
5:08	10,183	259.2	−51.4	−0.43	32	0.01	w.	49.0	
	11,000	228.8	−54.4	------	31	0.01	w.	51.0	
5:13	11,428	214.4	−55.9	0.36	30	0.01	w.	37.5	
	12,000	196.5	−55.7	------	27	0.01	w.	41.2	
	13,000	168.2	−55.5	------	22	[1]	------	------	
5:20	13,320	159.9	−55.4	−0.26	21	[1]	------	------	
5:23	13,772	149.2	−58.0	0.58	21	[1]	------	------	
	14,000	143.9	−58.0	------	21	[1]	------	------	
	15,000	123.0	−57.7	------	21	[1]	------	------	
5:30	15,141	120.3	−57.7	−0.22	21	[1]	------	------	
	16,000	105.2	−60.6	------	21	[1]	------	------	
5:35	16,521	96.9	−62.3	0.33	21	[1]	------	------	
	17,000	89.8	−62.0	------	------	------	------	------	
	18,000	76.7	−61.0	------	------	------	------	------	
5:51	18,519	70.7	−60.6	−0.85	------	------	------	------	

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 29, 1929

Time 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	*M.*	*Mb.*	*° C.*		*P. ct.*	*Mb.*		*M.p.s.*	
3:44	233	991.9	16.6	-------	32	6.05	sw.	5.8	Cloudless.
	500	961.1	14.6	-------	32	5.32	wsw.	8.6	
3:47	928	913.3	11.5	0.73	32	4.34	wsw.	10.6	
	1,000	905.4	11.0	-------	32	4.20	wsw.	11.3	
3:49	1,490	853.5	7.8	0.66	32	3.39	w.	19.0	
	1,500	852.5	7.8	-------	32	3.39	w.	19.0	
	2,000	802.3	6.9	-------	30	2.98	wnw.	17.5	
3:52	2,122	790.4	6.7	0.17	30	2.94	wnw.	16.9	
	2,500	754.7	4.9	-------	31	2.68	wnw.	16.2	
	3,000	709.7	2.4	-------	32	2.32	nw.	14.1	
3:59	3,711	649.9	−1.0	0.48	34	1.91	nw.	17.0	
	4,000	626.7	−2.5	-------	34	1.69	nw.	19.3	
	5,000	551.9	−7.7	-------	35	1.12	wnw.	20.8	
4:04	5,025	550.2	−7.8	0.52	35	1.11	wnw.	20.8	
	6,000	484.3	−16.2	-------	32	0.48	nw.	18.8	
4:11	6,626	446.0	−21.6	0.86	30	0.27	nnw.	23.2	
	7,000	423.8	−25.0	-------	30	0.19	nnw.	25.0	
4:15	7,728	383.1	−31.8	0.93	30	0.10	nw.	22.5	
	8,000	369.0	−33.7	-------	30	0.08	nw.	21.2	
	9,000	320.1	−40.9	-------	29	0.03	n.	26.6	
4:22	9,686	289.7	−45.8	0.66	28	0.02	n.	30.0	Tropopause.
	10,000	276.3	−45.9	-------	28	0.02	nnw.	23.1	
4:24	10,339	262.8	−46.0	0.03	28	0.02	nw.	19.8	
	11,000	238.5	−48.0	-------	27	0.01	nw.	29.6	
	12,000	205.5	−50.9	-------	26	0.01	nw.	34.6	
4:31	12,828	181.0	−53.4	0.30	25	0.01	nnw.	20.1	
	13,000	176.5	−54.0	-------	25	0.01	nnw.	23.6	
	14,000	151.4	−57.5	-------	25	(1)	nw.	20.2	
	15,000	129.5	−61.1	-------	25	(1)	nw.	20.0	
4:42	15,738	115.4	−63.7	0.35	25	(1)	nnw.	17.6	
	16,000	110.7	−63.8	-------	25	(1)	nnw.	13.3	
	17,000	94.4	−64.0	-------	25	(1)	nnw.	11.8	
4:50	17,555	86.4	−64.1	0.02	25	(1)	nnw.	14.6	
	18,000	80.5	−63.4	-------	25	(1)	nnw.	14.4	
4:54	18,550	73.6	−62.6	−0.15	25	(1)	nw.	20.2	

[1] Less than 0.01 mb.

LITERATURE CITED

(1) Annals Harvard College Observatory, Vol. 68, Pt. 1
(2) Monthly Weather Review, June 1929, pp. 231–246.
(3) Monthly Weather Review, July 1927, pp. 293–307.

WIND VELOCITIES AT DIFFERENT HEIGHTS ABOVE GROUND

By C. F. MARVIN

A correspondent inquires whether the Weather Bureau has made any investigations to determine the relative wind velocity as indicated by an anemometer at different heights above ground. The following reply was made:

Replying to your telegram of August 21, requesting information as to velocities indicated by anemometers at different heights above the ground, you are advised that the Weather Bureau has conducted a number of inconclusive comparisons of wind velocities measured at its stations at different elevations, with the hope that some rational rule would result for coordinating the indications at various heights. Thus far, however, we have not felt justified in announcing any such coordination or formula, so to speak, for reduction to uniform elevations.

The demands upon the bureau for service to the public in great metropolitan and other city areas compel us to occupy quarters such as can be procured in these cities. It is recognized that the wind-velocity records obtained under these conditions are not entirely satisfactory. If one contemplates the skyline of the modern great city, it is obvious that the flow of air over the house tops and among the skyscrapers is turbulent and difficult to measure with any specially significant result. On the other hand, observations made in the open country or in cities of moderate population necessarily represent only those localities, and can not, with assurance, be applied to other localities. Our policy, therefore, has been to submit records as obtained, without attempting to modify or adjust these records, and to supply to any interested person a complete description of the environment and nature of exposure of the anemometer at the particular station, leaving it to the user of the records to make such correlations with environment as may seem to him to be best.

Apart from the foregoing, you are further advised that various comparative observations have been made for winds at different altitudes over an open plain or country, and one formula for increase of velocity is approximately

$$V = V_o\left(\frac{h}{h_o}\right)^{\frac{1}{5}}$$

where h is the height in meters above the surface for which the velocity V in meters per second is to be computed, and h_o the known height (not less than 16 meters) at which the velocity V_o is measured. There are still other relations that cover the general increase in velocity upward for much greater elevations. I infer, however, that you are interested only in elevations of several hundred feet above the actual surface.

THE WEATHER AND RADIO

By W. J. HUMPHREYS

It appears to be human nature to explain whatsoever is not understood by attributing it to something that is still more mysterious, or even to the supernatural. At any rate this is a very common human practice, as excellently illustrated by the many appeals that have come to the Weather Bureau to have radio broadcasting suppressed, on the ground that it is burning up the water vapor of the air and thereby, or in some other manner, greatly decreasing the amount of rainfall, and thus causing disastrous droughts.

On the other hand, some who were bothered with more rain than needed were equally insistent that radio is the cause of excessive precipitation and floods, and urged that therefore all wireless communication be forthwith and preemptorily forbidden.

Let us analyze somewhat nature's way of making rain, and from that see, if we can, just how and to what extent radio does affect precipitation.

1. The first action necessary to precipitation is evaporation, by which water in the gaseous form is gotten into and made a portion of the atmosphere. Now the chief factors that affect the rate of evaporation are: (*a*) Temperature of the evaporating water; (*b*) area of the evaporating surface; (*c*) wind velocity; (*d*) dryness of the air. Of course no one in the neighborhood of a powerful "sending station" ever claims that any lake, reservoir or other body of water near-by, spreads over a lot more ground when the station is in operation than it does when the station is silent. He knows, too, that the temperature of the water does not appreciably vary, if at all, with the wireless activity. Neither, so far as any one can observe, does the wind round about a wireless station change with the amount of its broadcasting or receiving. We shall see presently, too, that radio does not alter the dryness of the air.

Obviously, since radio does not affect any of the things that themselves make for evaporation, neither does it affect evaporation itself.

2. The next step by nature in producing rain is to condense the water vapor out of the air in the form of drops. To this end two things are necessary: (*a*) One of these is the presence of condensation nuclei, that is, excessively small particles of sea salt, certain kinds of land dust, or other substances that readily take up water vapor. These nuclei about which cloud droplets form always are in the atmosphere in superabundance. Besides, they are not produced by wireless waves, as we know by direct experiment. (*b*) The other essential to